Integrated Wetland, Aquatic and Rehabilitation Assessment for the proposed Expansion of the Mooiplaats Colliery Underground Mining Operation

Ermelo, Mpumalanga, South Africa

June 2019

CLIENT

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<tr><td>Declaration</td><td colspan="2">The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Ecological Assessment Regulations, 2017. We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time and budget) based on the principals of science.</td></tr>
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Declaration

I, **Tyron Clark** 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.

Tyron Clark

Wetland and Terrestrial Ecologist

The Biodiversity Company

24th of July 2019

1 Introduction

Coal of Africa intends to expand its underground mining operations at the Mooiplaats Colliery near Ermelo, Mpumalanga. Although the colliery has an approved Mining Right MP 30/5/1/2/2/68 MP, 2007 (MR) and Integrated Water Use Licence No. 08/C11B/AGJ/2141, 02 May 2013 it currently does not cover the area into which expansion is planned. In response The Biodiversity Company (TBC) was appointed to provide specialist input, from a wetlands and aquatics perspective, towards the application to amend the existing water use licence to include expansion into proposed mining areas. These areas include Portions 0, 2 and 3 of the farm Klipbank 295 IT, Portions 0,1 and 2 of the farm Adrianople 296 IT as well as Portions 1, 2, 7, 8, and 9 of the farm Mooiplaats 290IT. Specifically TBC was tasked with (1) updating the existing wetland report for the active mining area, (2) providing a baseline wetland and aquatic assessment (with impacts) for the proposed expansion areas, (3) providing a rehabilitation plan for wetlands in the active mining area and (4) input from a hydropedolgical perspective into the construction of the two proposed vent shaft areas. This report addresses the first two aspects in a single integrated report.

This assessment was conducted in accordance with the 2014 EIA Regulations (No. R. 982-985, Department of Environmental Affairs, 4 December 2014) emanating from Chapter 5 of the National Environmental Management Act (Act No. 107 of 1998). The findings and information herein are in terms of Appendix 6 of the 2014 NEMA EIA Regulations (amended in 2017).

2 Terms of Reference

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

- The delineation and assessment of water resources within the entire project area;
- A single integrated report that provides both an updated account of wetlands within the existing mine area as well as a baseline and impact assessment for the proposed underground mining expansion areas.
- An ecological integrity (health) assessment of water resources;
- An ecosystem services assessment of water resources;
- Assessment of impacts associated with the proposed activities; and
- Prescription of mitigation for the associated impacts.

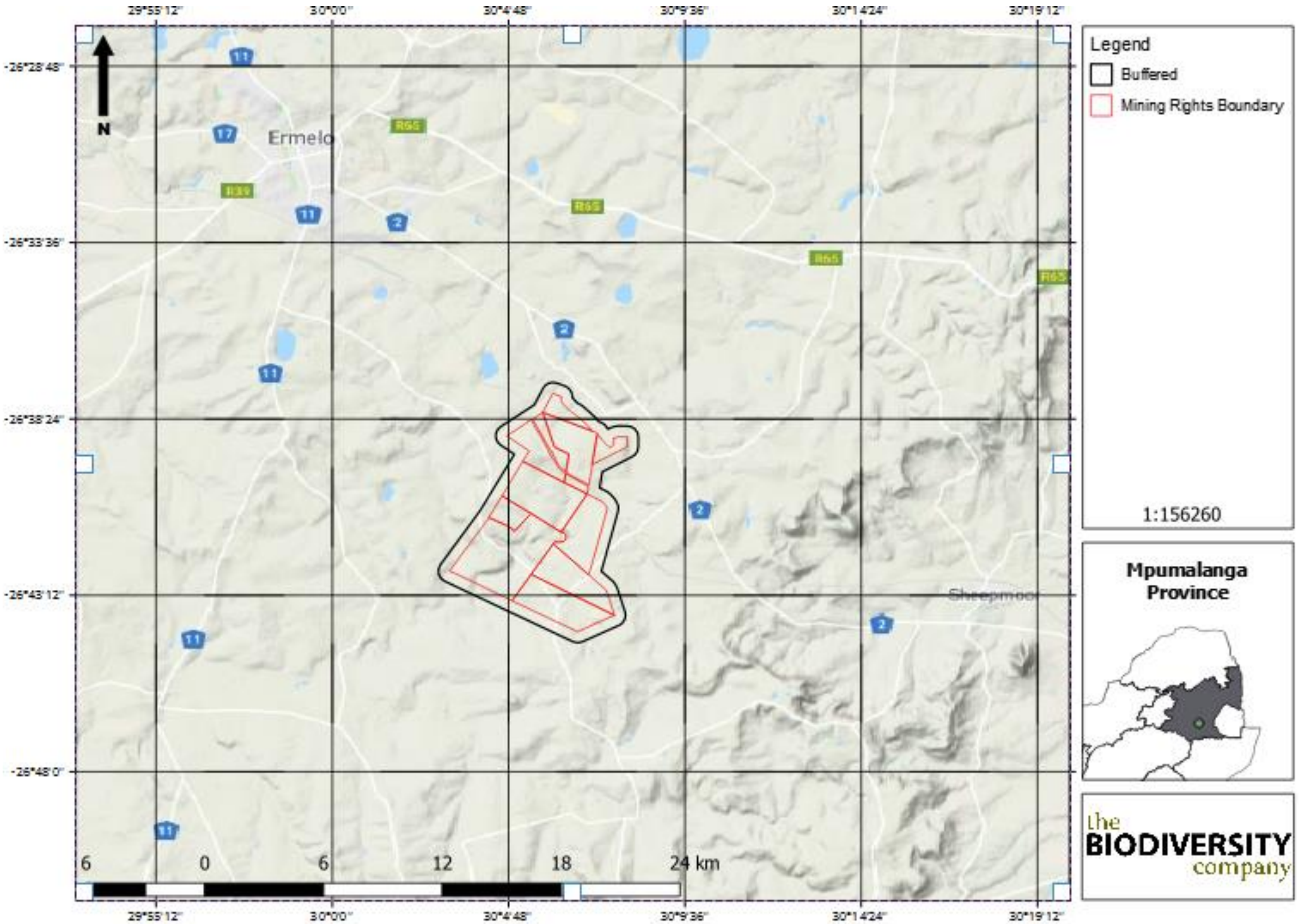


Figure 1: Locality map

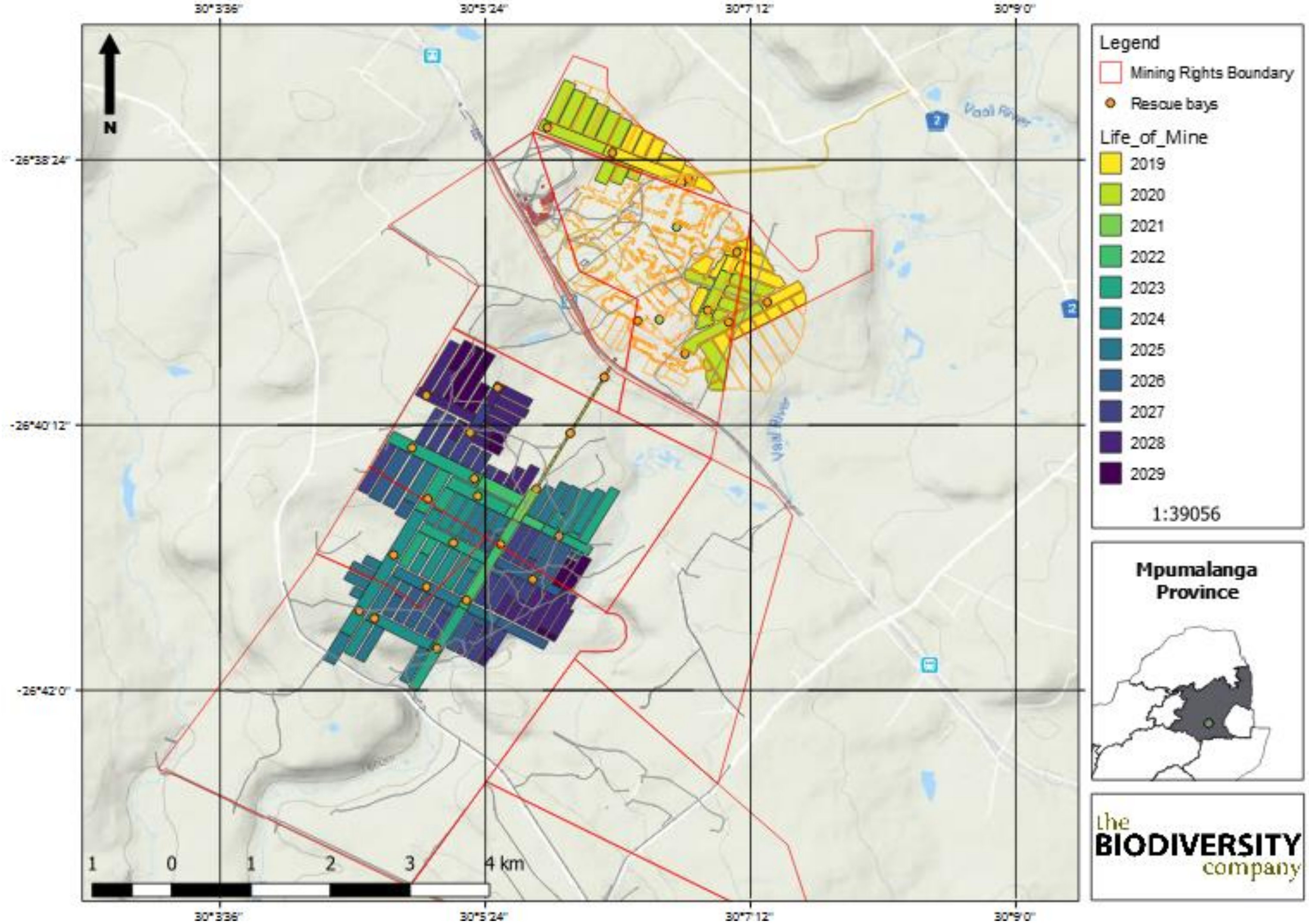


Figure 2: The life of mine for the project, location of mining resources

3 Receiving Environment

3.1 Prevailing Land Uses

The prevailing land uses within the project area centre on commercial crop cultivation, livestock grazing (predominantly cattle) and game farming. The majority of the landscape is in a natural state and is relatively devoid of alien and invasive species. Other land uses within the project area includes agricultural properties and cultivated fields; various secondary farm roads and minor tar roads; power lines – especially Eskom powerlines transecting multiple farm portions; telephone lines; and agricultural homesteads. Figure 3 provides examples of the dominant land uses.

Figure 3: Dominant land uses within the project area; A) largely natural areas, B) mines and power stations, C) livestock farming, D) past (fallow lands) and current crop agriculture

3.2 Mpumalanga Biodiversity and Freshwater Sector Plans

The key output of a systematic biodiversity plan is a map of biodiversity priority areas (MTPA, 2014). In 2006 the MTPA and the Department of Agriculture and Land Administration (DALA) initiated the development of the Mpumalanga Biodiversity Conservation Plan (MBCP). As the first such plan produced for the Province, it was intended to guide conservation and land-use decisions in support of sustainable development. The MBCP provided a spatial framework that supported land-use planning and helped to streamline and monitor environmental decision-making (Ferrar & Lotter, 2007). Since 2007, several technical advances and land use changes necessitated the need for an update of the MBCP. This resulted in the production of the Mpumalanga Biodiversity and Freshwater Sector Plans which provide a more comprehensive assessment of the biodiversity of the terrestrial and freshwater environment in Mpumalanga (MTPA, 2014). These sector plans classify all land areas within the province into Critical Biodiversity Areas (CBAs), Ecological Support Areas (ESAs), Other Natural Areas (ONAs), Protected Areas (PAs), and areas that have been irreversibly modified from their natural state (MTPA, 2014). The MBSP uses the following terms to categorise the various land used types according to their biodiversity and environmental importance:

CBAs are terrestrial and aquatic areas of the landscape that need to be maintained in a natural or near-natural state to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services. CBAs are areas of high biodiversity value and need to be kept in a natural state, with no further loss of habitat or species (MTPA, 2014). Thus, if these areas are not maintained in a natural or near natural state then biodiversity targets cannot be met. Maintaining an area in a natural state can include a variety of biodiversity compatible land uses and resource uses (BGIS, 2017).

CBAs are areas of high biodiversity value and need to be kept in a natural state, with no further loss of habitat or species (MTPA, 2014). <u>These areas are therefore incompatible with mining developments.</u>

The Mpumalanga Biodiversity Sector Plan (MBSP) specifies two different CBA areas, Irreplaceable CBA's and Optimal CBA's. Irreplaceable CBA's include: (1) areas required to meet targets and with irreplaceability biodiversity values of more than 80%; (2) critical linkages or pinch-points in the landscape that must remain natural; or (3) critically Endangered ecosystems (MTPA, 2014).

ESAs are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of Critical Biodiversity Areas and/or in delivering ecosystem services. Critical Biodiversity Areas and Ecological Support Areas may be terrestrial or aquatic (SANBI-BGIS, 2017).

ONAs consist of all those areas in good or fair ecological condition that fall outside the protected area network and have not been identified as CBAs or ESAs. A biodiversity sector plan or bioregional plan must not specify the desired state/management objectives for ONAs or provide land-use guidelines for ONAs (SANBI-BGIS, 2017).

Moderately or Heavily Modified Areas (sometimes called 'transformed' areas) are areas that have been heavily modified by human activity so that they are by-and-large no longer natural, and do not contribute to biodiversity targets (MTPA, 2014). Some of these areas may still provide limited biodiversity and ecological infrastructural functions but, their biodiversity value has been significantly, and in many cases irreversibly, compromised.

Analysis of the MBSP spatial data reveals that a portion of the project area (Portion 3 of the farm Klipbank 295 IT) is zoned as a protected area. The majority of the remaining areas are zoned as Critical Biodiversity Areas (Figure 4). Analysis of the MBSP spatial data reveals that that the two main Floodplain systems within the project area (the Vaal and an un-named tributary) are classified as CBAs. Most of the other systems within the expansion areas are zoned as ESAs while those associated with the existing mining areas are zoned as ONAs.

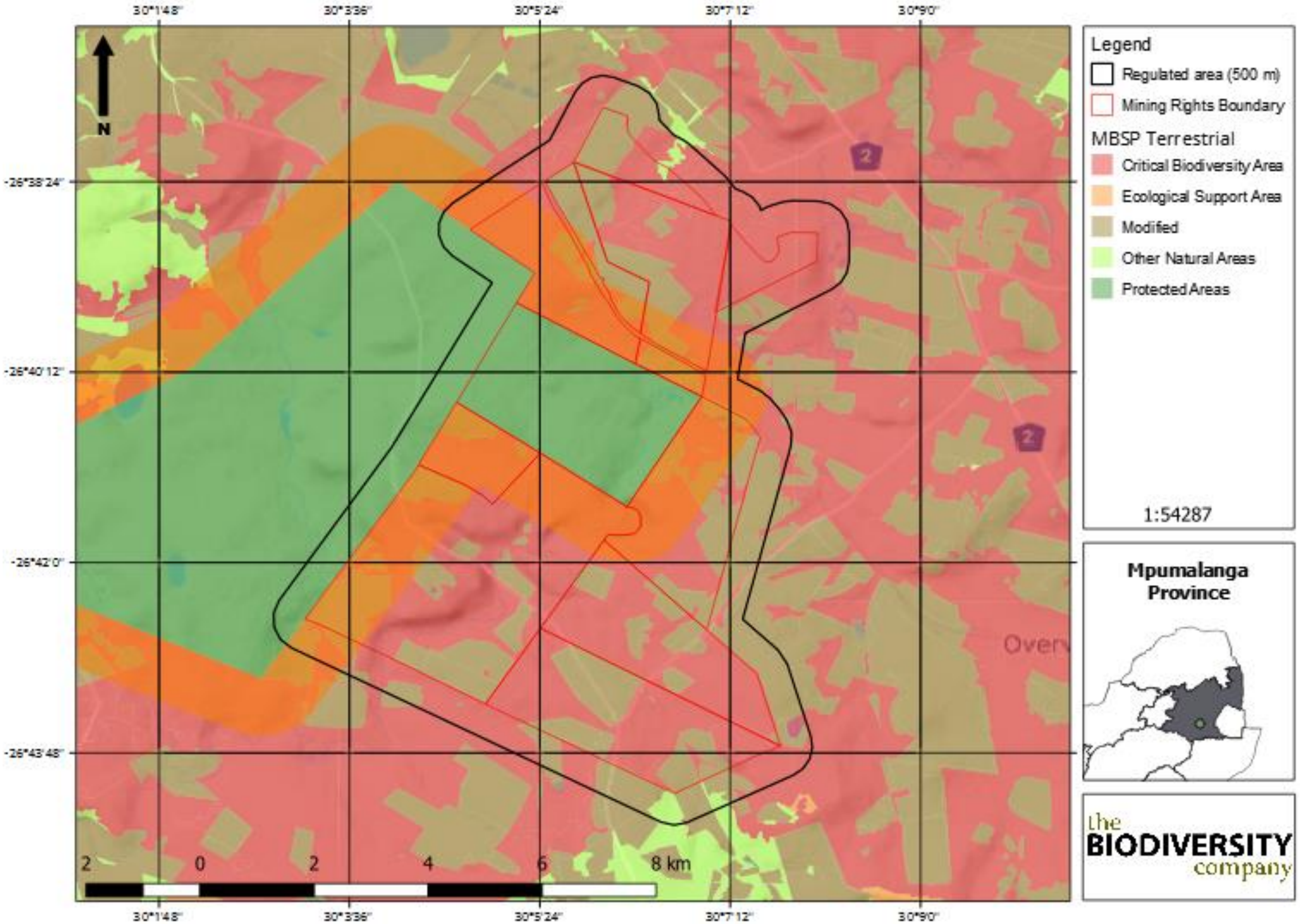


Figure 4: Mpumalanga Biodiversity Sector Plan

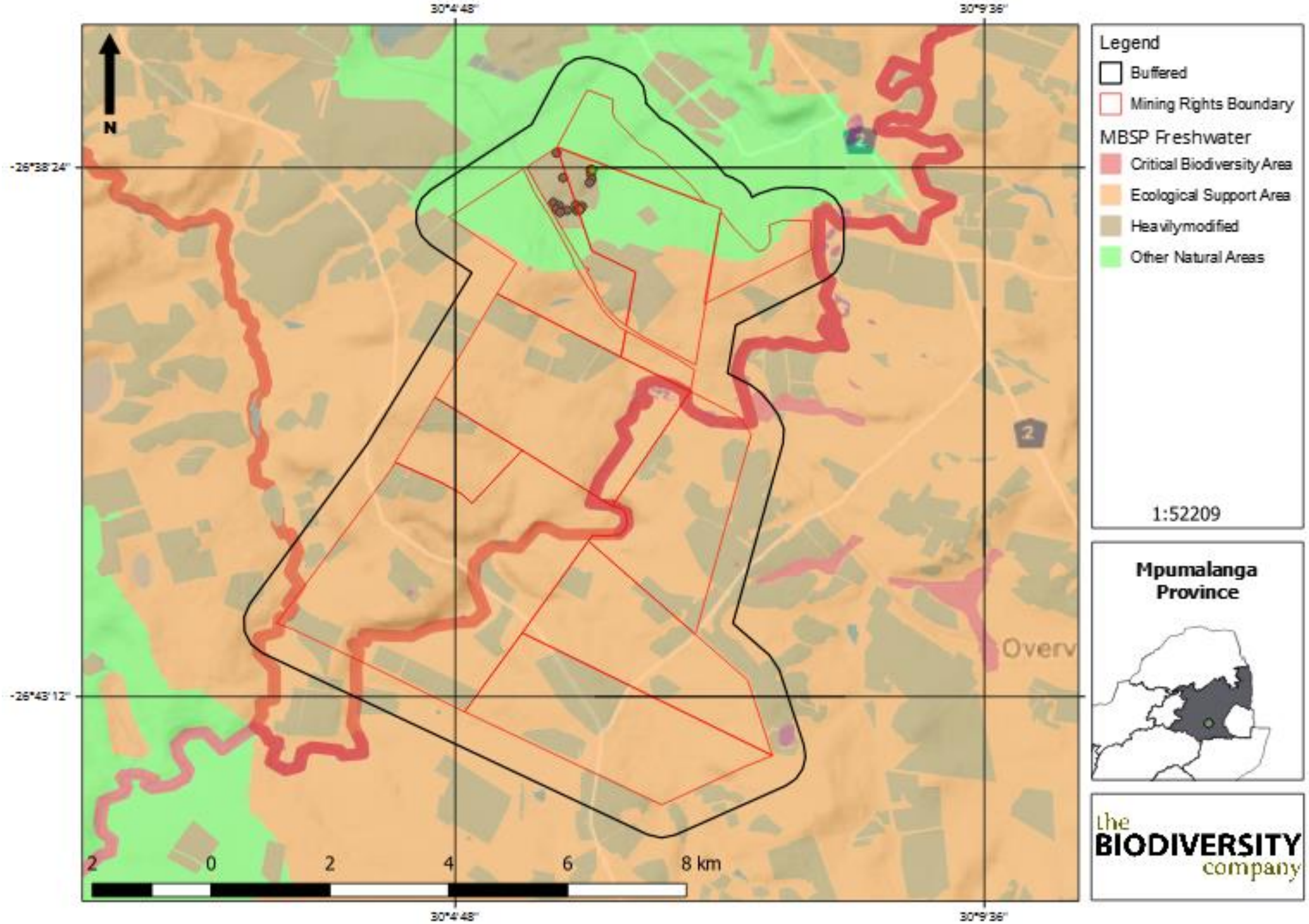


Figure 5: Mpumalanga Freshwater Sector Plans

3.3 National Freshwater Ecosystem Priority Areas

In an attempt to better conserve aquatic ecosystems, South Africa has categorised its river systems according to set ecological criteria (i.e. ecosystem representation, water yield, connectivity, unique features, and threatened taxa) to identify Freshwater Ecosystem Priority Areas (FEPAs) (Driver *et al.,* 2011). The FEPAs are intended to be conservation support tools and envisioned to guide the effective implementation of measures to achieve the National Environment Management Biodiversity Act (NEM:BA) biodiversity goals (Nel *et al.,* 2011).

3.3.1 NFEPA Rivers

Figure 6 shows the location of the project area in relation to River FEPAs. Based on this information, the two main floodplains within the project area traverses are recognised a Phase 1 FEPAs Rivers namely the Vaal (which runs through the centre of the site) and an Un-named tributary of it in the south. Additionally, The Witpuntspruit is recognised as an Upstream Management Area (Phase 4 FEPA).

3.3.2 NFEPA Wetlands

Figure 7 shows the location of the project area in relation to wetland FEPAs. From this map it is evident the northern half of the Vaal Floodplain within the expansion area is a wetland FEPA. Several small depressions in the south have also been included as wetland FEPAs.

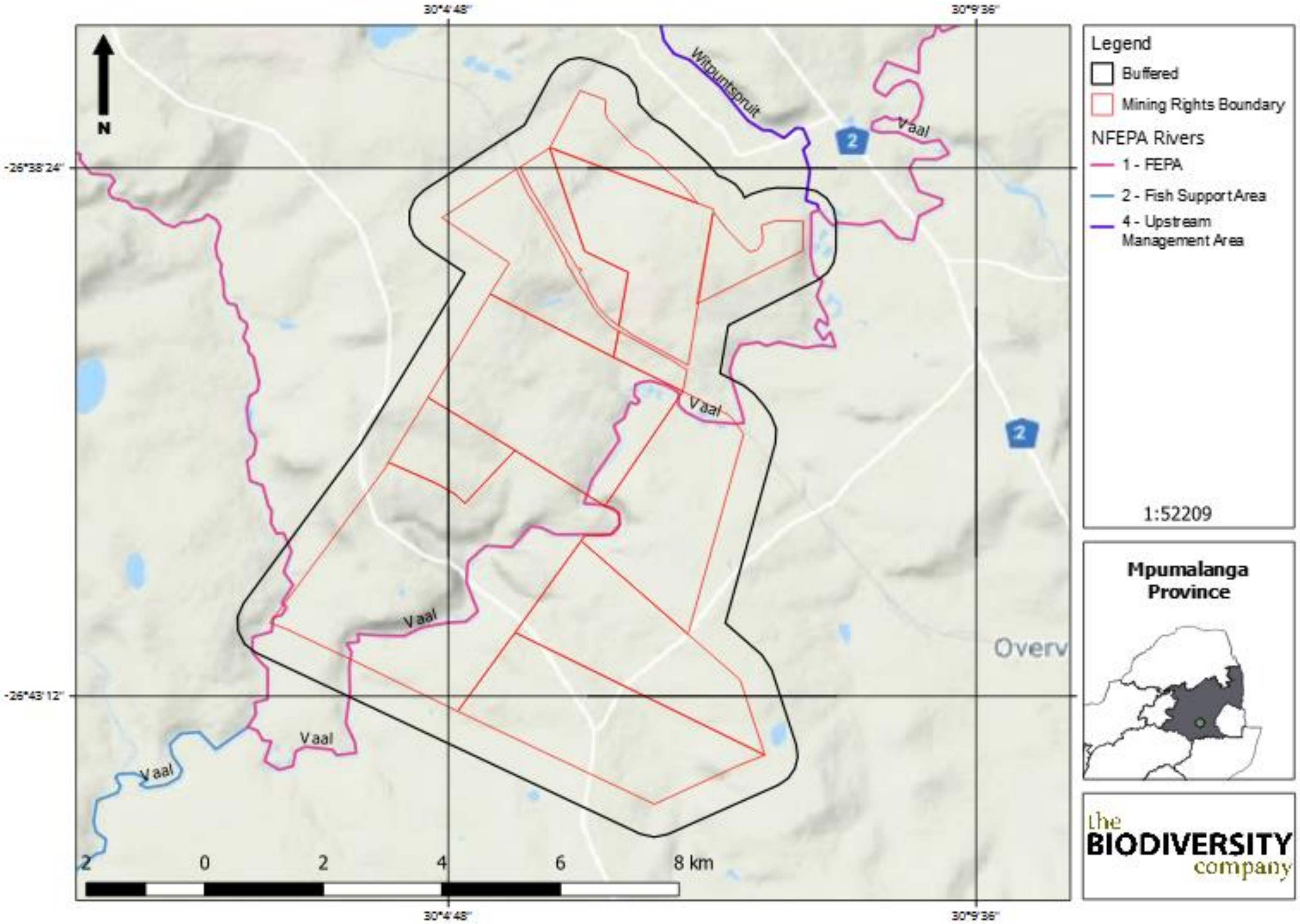


Figure 6: NFEPA Rivers within and surrounding the project area

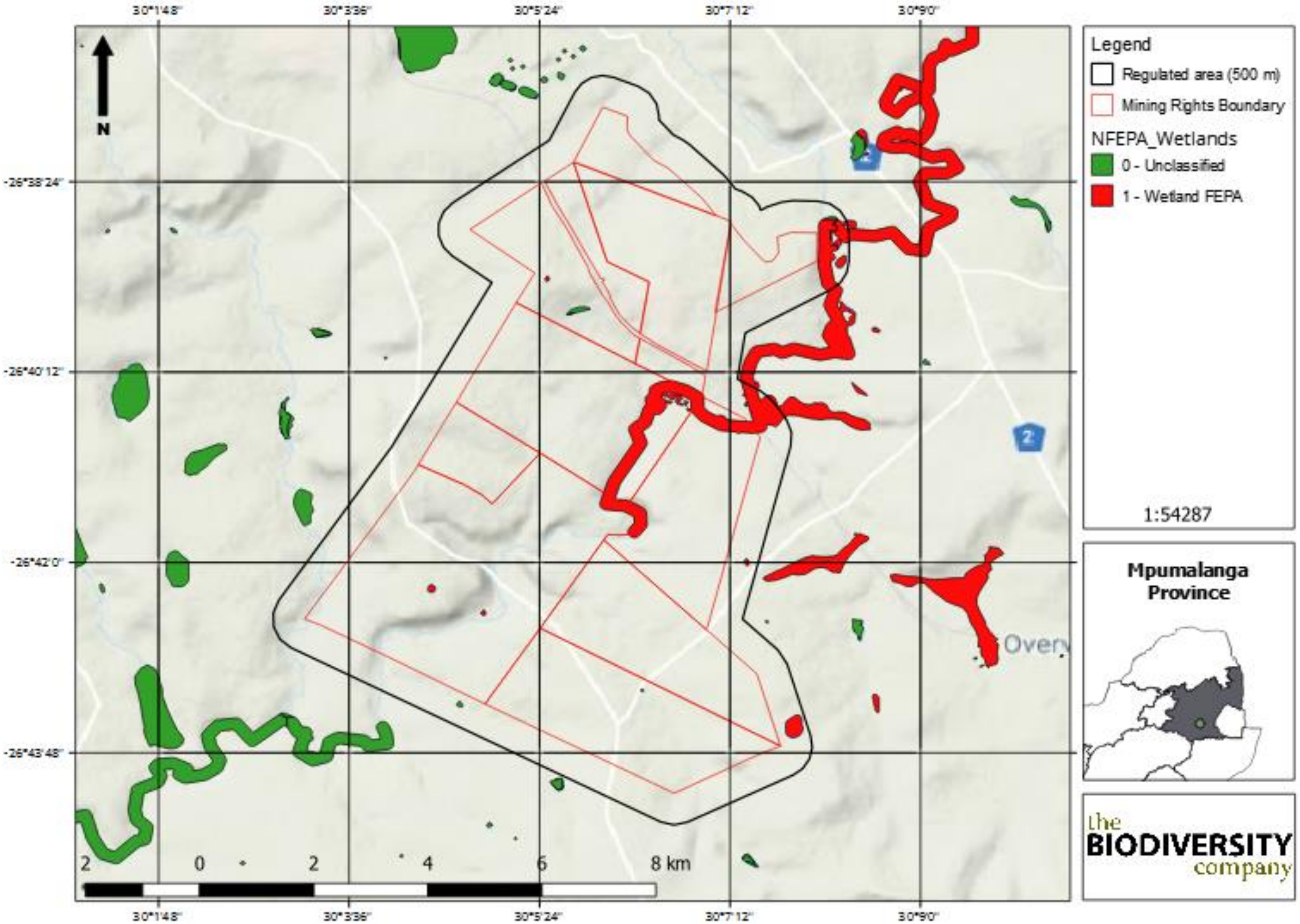


Figure 7: NFEPA Wetlands within and surrounding the project area

4 Key Legislative Framework

All legal implications should be considered prior to the commencement of any rehabilitation activities and the relevant environmental authorisations and / or licences obtained. Applicable legislation includes, but is not limited to:

- The National Environmental Management Act 107 of 1998 (NEMA).
  - Section 24N relating to EMPr provisions
  - Section 24P relating to financial provisions for remediation of environmental damage
  - Section 24R relating to mine closure
  - section 28 relating to duty of care; and
  - Section 30 and Section 30A relating to emergency incidents.
- The 2014 Environmental Impact Assessment (EIA) Regulations published under NEMA.
- The National Water Act 36 of 1998 (NWA).
- The Waste Act – including Chapter 8 relating to the provisions on contaminated land.
- The applicable General Authorisations in terms of section 39 of NWA.
- The National Environmental Management: Biodiversity Act 10 of 2004 (NEM:BA, hereafter referred to as Biodiversity Act).
- The Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA), with authorisation under various pieces of legislation usually required.
- The Alien and Invasive Species Regulations published in the Government Gazette No. 37886, 1 August 2014, as amended in February 2018 in the Government Gazette No. 41445.

5 Methodology

5.1 Wetland Assessment

5.1.1 Wetland Identification and Mapping

The wetland areas were delineated in accordance with the DWAF (2005) guidelines, a cross section is presented in Figure 8. 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 one of the primary indicators. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role.

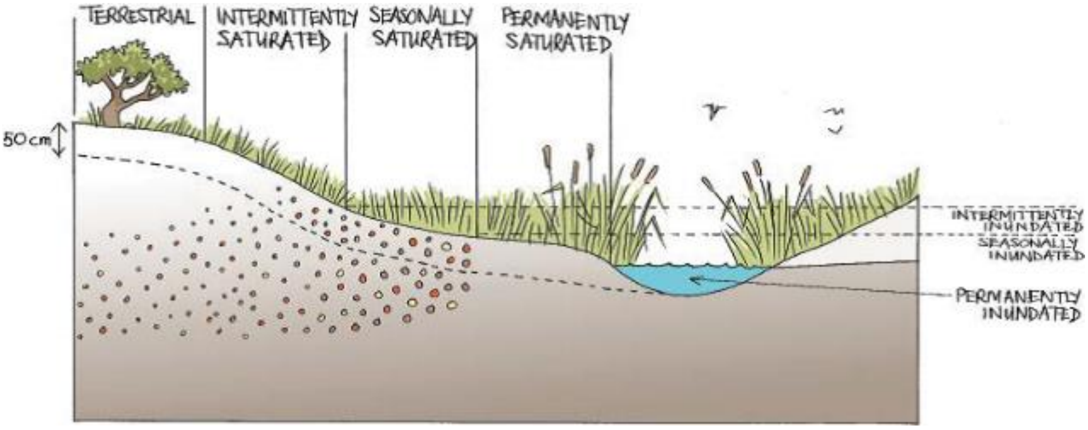


Figure 8: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change (Ollis et al. 2013)

5.1.2 Wetland Delineation

The wetland indicators described in "5.1" were used to determine the boundaries of the wetlands within the project area. These delineations are then illustrated by means of maps accompanied by descriptions.

5.1.3 Wetland Functional Assessment

Wetland Functionality refers to the ability of wetlands to provide healthy conditions for the wide variety of organisms found in wetlands as well as humans. Eco Services serve as the main factor contributing to wetland functionality.

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 1).

Table 1: 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

5.1.4 Determining the Present Ecological Status of wetlands

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 2.

Table 2: The Present Ecological Status categories (Macfarlane, et al., 2009)

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

5.1.5 Determining the Ecological Importance and Sensitivity of Wetlands

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 3, (Rountree and Kotze, 2013).

Table 3: Description of Ecological Importance and Sensitivity categories

EIS Category	Range of Mean	Recommended Ecological Management Class
Very High	3.1 to 4.0	**A**
High	2.1 to 3.0	**B**

Moderate	1.1 to 2.0	**C**
Low Marginal	< 1.0	**D**

5.1.6 Ecological Classification and Description

The National Wetland Classification Systems (NWCS) developed by the South African National Biodiversity Institute (SANBI) will be 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, and then also includes structural features at the lower levels of classification (Ollis *et al.* 2013).

5.1.7 Determining Buffer Requirements

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.

5.2 Aquatic Assessment

5.2.1 *In Situ* Water Quality

During the survey a portable Exstick 2 multimeter was used to measure the following parameters *in situ*:

- pH;
- Conductivity;
- Dissolved Oxygen (DO); and
- Water Temperature.

Water quality has a direct influence on aquatic life forms. Although these measurements only provide a "snapshot", they can provide valuable insight into the characteristics and interpretation of a specific sample site at the time of the survey.

5.2.2 Habitat Assessment

Habitat availability and diversity are major attributes for the biota found in a specific ecosystem, and thus knowledge of the quality of habitats is important in an overall assessment of ecosystem health. Habitat assessment can be defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour *et al*. 1996). Both the quality and quantity of available habitat affect the structure and composition of resident biological communities (USEPA, 1998). Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason, habitat evaluation is conducted simultaneously with biological evaluations to facilitate the interpretation of results.

5.2.2.1 Intermediate Habitat Integrity Assessment (IHIA)

The aim of the Intermediate Habitat Integrity Assessment (IHIA) is to make an intermediate assessment of the habitat integrity of rivers according to a modified Habitat Integrity approach which can be applied in intermediate determination of the ecological Reserve for rivers in South Africa (DWS, 1999). The methodology is based on the qualitative assessment of a number of pre-weighted criteria which indicate the integrity of the in-stream and riparian habitats available for use by riverine biota.

The criteria considered indicative of the habitat integrity of the river were selected on the basis that anthropogenic modification of their characteristics can generally be regarded as the primary causes of degradation of the integrity of the river (Table 4) (DWS, 1999). The study assessed 5 km of the Witpuntspruit, and 5 km of the Vaal River.

Table 4: Criteria used in the assessment of habitat integrity (from Kleynhans, 1996).

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et al*., 1993 in: DWS, 1999). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993 in: DWS, 1999) 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 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 (Gordon *et al*., 1992 in DWS, 1999)).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon *et al*., 1992). 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.

The assessment of the severity of impact of modifications is based on six descriptive categories which are described in Table 5.

Table 5: Descriptive classes for the assessment of modifications to habitat integrity (from Kleynhans, 1996).

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**

The habitat integrity assessment takes into account the riparian zone and the instream channel of the river. Assessments are made separately for both aspects, but data for the riparian zone are primarily interpreted in terms of the potential impact on the instream component (Table 6). The relative weighting of criteria remain the same as for the assessment of habitat integrity (DWS, 1999).

Table 6: Criteria and weights used for the assessment of habitat integrity and habitat integrity (from Kleynhans, 1996).

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
Total	100	**Total**	100

The negative weights are added for the instream and riparian facets respectively and the total additional negative weight subtracted from the provisionally determined intermediate integrity to arrive at a final intermediate habitat integrity estimate. The eventual total scores for the instream and riparian zone components are then used to place the habitat integrity in a specific intermediate habitat integrity category (DWS, 1999). These categories are indicated in Table 7.

Table 7: Intermediate habitat integrity categories (From Kleynhans, 1996)

Category	Description	Score (% of Total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0

5.2.3 Aquatic Macroinvertebrates

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.

5.2.3.1 South African Scoring System version 5

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).

Reference conditions reflect the best conditions that can be expected in rivers and streams within a specific area and reflect natural variation over time. These reference conditions are used as a benchmark against which field data can be compared. Modelled reference conditions for the Highveld - Lower Ecoregions were obtained from Dallas (2007). The biological bands for the Highveld - Lower Ecoregion are presented in Figure 9. Ecological categories based on biological banding are presented in Table 8.

Table 8: 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.

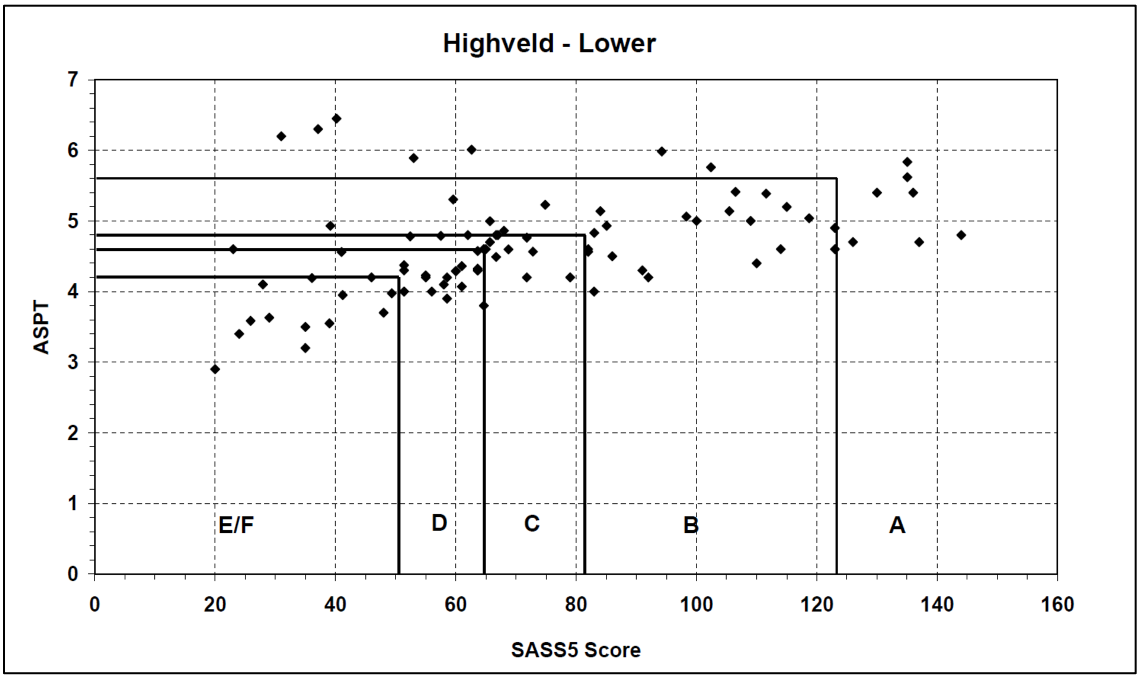


Figure 9: Biological Bands for the Highveld – Lower Ecoregion, calculated using percentiles (Dallas, 2007)

5.2.4 Macroinvertebrate Response Assessment Index

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

- Flow regime;
- Physical habitat structure;
- Water quality;
- Energy inputs from the watershed; and

- 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.

5.2.5 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.

5.2.6 Present Ecological Status

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

5.3 Limitations

The following aspects were considered as limitations:

- The use of two of the main wetland indicators namely hydromorphic soils and hydrophytic vegetation was somewhat limited in some of the seep areas that have been extensively transformed through commercial crop cultivation practices;
- Whilst every effort is made to groundtruth and assess all wetland systems, it is not possible assess the entire extent of the project area. A combination of professional experience, desktop data and survey findings are used to reduce this limitation as much as possible, and extrapolation of data and satellite imagery is used for delineations in these areas;
- Wetlands within the 500 m regulated area were considered but not explicitly sampled and delineated in-field, wetland delineations within these areas should be considered desktop;
- The GPS used for water resource delineations is accurate to within five meters. Therefore, the wetland delineation plotted digitally may be offset by at least five meters to either side;
- A wetland buffer zone was not determined for the proposed underground mining areas, but a recommended buffer area has been determined for the proposed ventilation shafts;

- The information provided herein for the aquatic assessment was incorporated from the ongoing biomonitoring being undertaken for Mooiplaats Colliery. Information herein is incorporated from the 2018 aquatic biomonitoring programme. This report should be read on conjunction with the biomonitoring report; and
- Aquatic sampling points are located in the vicinity of the active mining area and are associated with the Vaal and Witpuntspruit systems.

6 Results and Discussion

6.1 Wetland Assessment

The project area and associated wetlands are situated in the upper reaches of the Vaal River catchment. These systems form part of the Upper Vaal Water Management Area and are zoned under Quaternary catchment C11B. In the north (existing mining area) water drains in a north-easterly direction towards the Witpuntspruit. This river runs to the north of the project area before merging with the Vaal while in the south, a network of seeps and valley-bottom wetlands direct water towards the Vaal River Floodplain. This large, well developed floodplain flows in a south-westerly direction, effectively bisecting the expansion area. A further 6.5 km downstream it is joined by the Klein Vaal. The deeply incised topography of the expansion area has likely aided in the protection of its wetland systems which remain, for the most part, in a relatively intact state. Studies by Gradient Consulting, (2019) suggest that the overall ground and surface water quality is good with most analysed parameters falling below the SANS 241:2015 limits with exception of a few locations where fluoride, nitrate as well as heavy metals i.e. manganese and iron are elevated.

Figure 10: Reach of the Vaal River Floodplain (crossing along main access route)

6.1.1 Wetland Classification

For the purposes of this assessment, the delineated and assessed wetland HGM units have been grouped per drainage areas or watersheds. This has allowed for the grouping of similar HGM units into three (3) separate groups. This grouping of HGM units is supported by the topography of the area, but also the similar land uses and project area characteristics across the larger project area. The three groups are associated with the main watercourses into which they drain, namely the Vaal (located centrally), Witpuntspruit (situated in the north) and Vaal Southern Tributary (located in the south-west). The largest grouping of HGM units is associated with the Vaal River Floodplain which effectively bisects the expansion area. Figure 11 presents a digital elevation model and the associated stream orders identified for the area, depicting the three key drainage areas. *Figure 12* presents the spatial extent of the delineated wetland areas (or groups) delineated for this project. In total over 68 discrete wetland areas were delineated during the survey within the project area and surrounding 500 m regulated area. Results of the level 1-4 wetland classification for the wetland systems within the project area are presented in (Figure 13). Photographs of some of the soil forms and vegetation identified for the project are presented in Figure 14.

Wetlands within the three groups were subject to a 1-4 level ecological classification as per the national classification system (Ollis *et al*. 2013) (Table 9). It is important to note that per Ollis *et al*. (2013) the active channel was excluded from the ecological and ecosystem services assessments. This yielded a total of nine (9) hydrogeomorphic (HGM) units belonging to four main hydrogeomorphic types namely floodplains, channelled and unchanneled valley-bottoms, seeps and depressions (Figure 13). A brief description of the three assessed HGM Units is provided below. Conceptual illustrations of the wetlands, showing the typical landscape setting and the dominant inputs, throughputs and outputs of water are presented in Figure 15 (Ollis *et al*., 2013).

Table 9: Wetland classification as per SANBI guideline (Ollis et al. 2013)

HGM Code	Level 2		Level 3	Level 4		
	Eco-region	NFEPA Wet Veg Group	Landscape Unit	4A	4B	4C
Vaal						
1	11	MHGG4	Valley floor	Floodplain	NA	NA
2	11	MHGG4	Slope	Channelled valley-bottom	NA	NA
3	11	MHGG4	Slope	Unchanneled valley-bottom	NA	NA
4	11	MHGG4	Slope	Seep	NA	NA
5	11	MHGG4	Bench	Depression	NA	NA
Witpuntspruit						
6	11	MHGG4	Slope	Unchanneled valley-bottom	NA	NA
7	11	MHGG4	Slope	Seep	NA	NA
Vaal Southern Tributary						
8	11	MHGG4	Valley floor	Floodplain	NA	NA
9	11	MHGG4	Slope	Seep	NA	NA

MHGG4, Mesic Highveld Grasslands Group 4

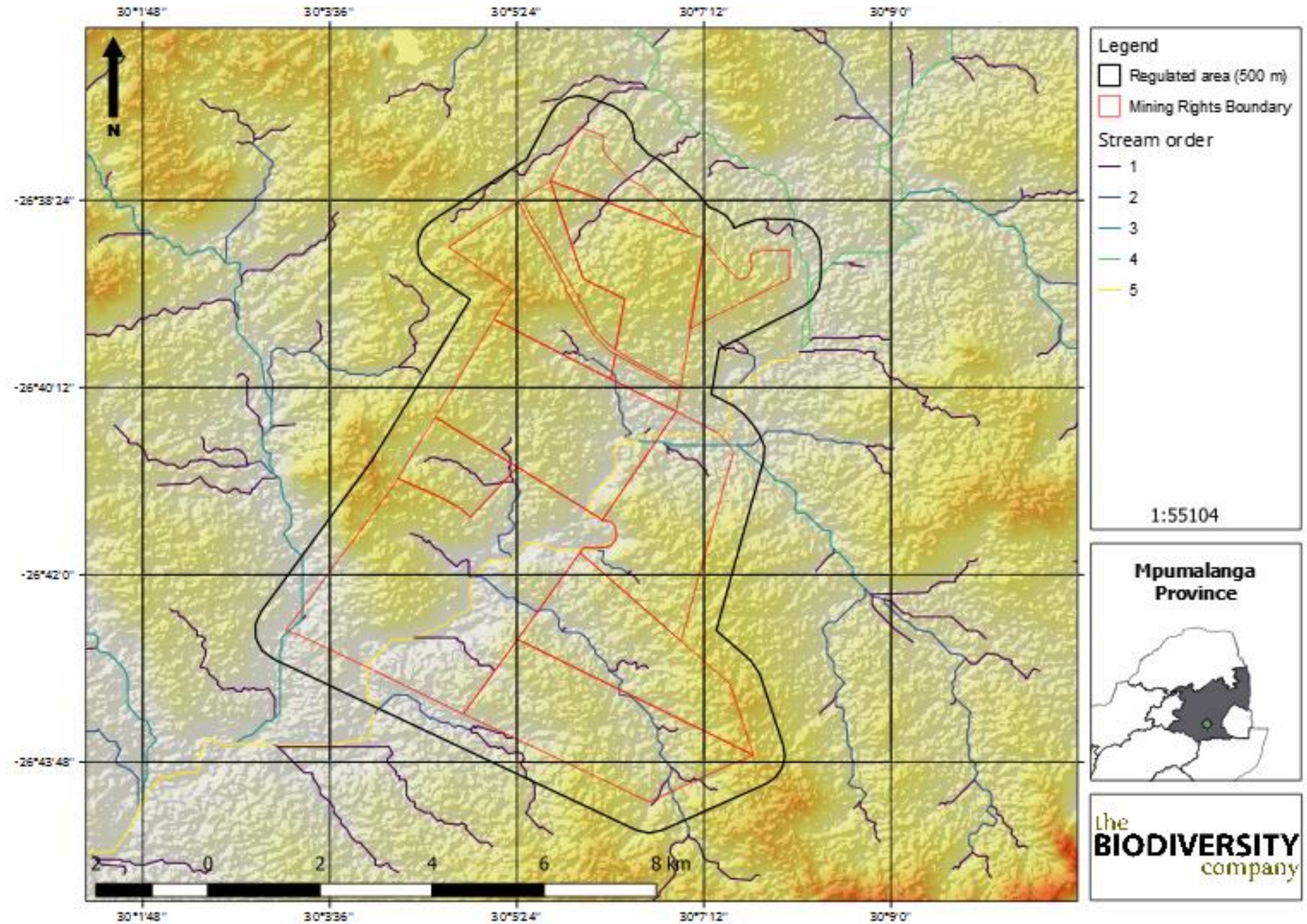


Figure 11: Digital elevation model showing drainage network and stream order

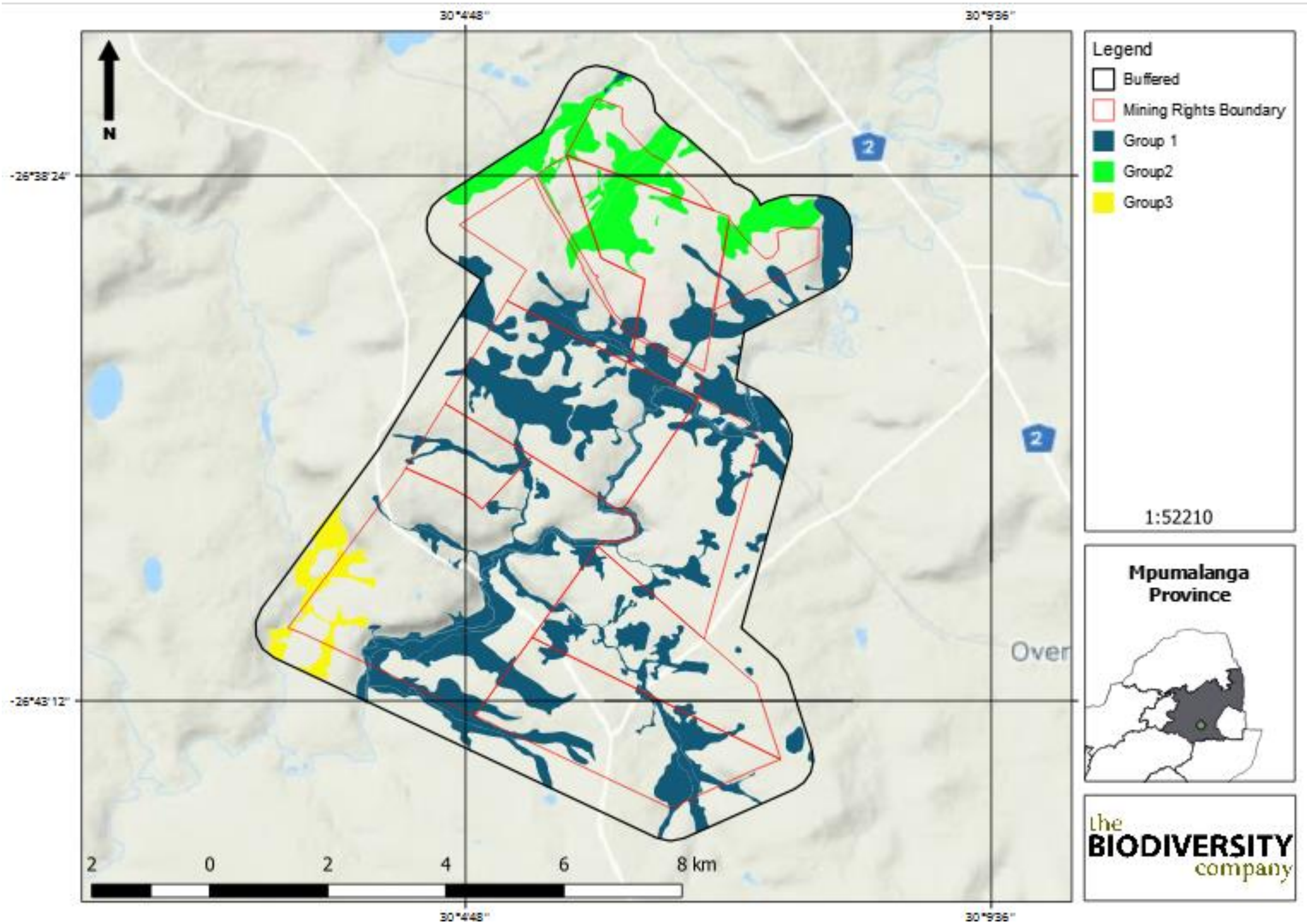


Figure 12: Three main wetland groups

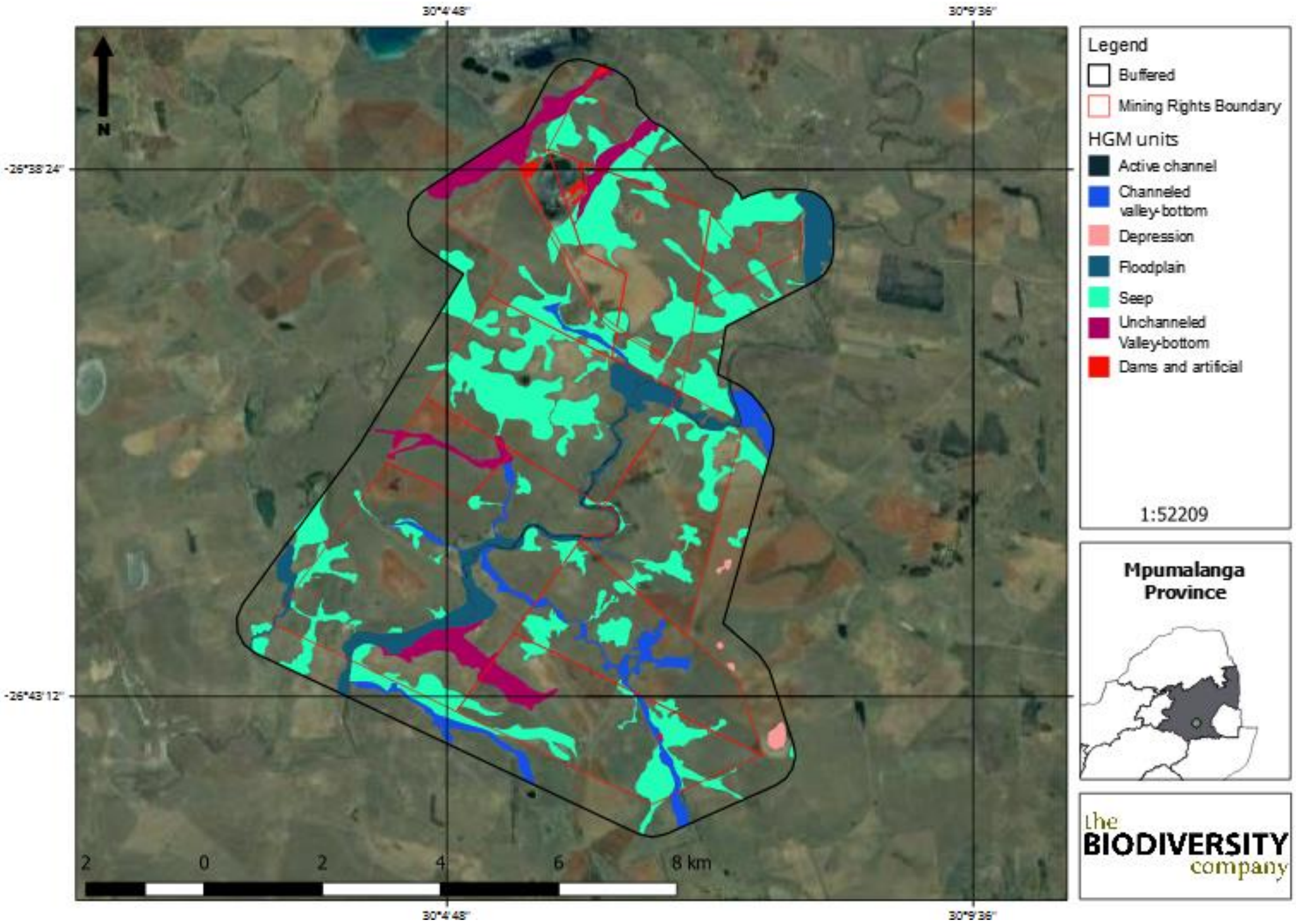


Figure 13: Wetland HGM units

Figure 14: Examples of the main wetland HGM types identified within the project are; A) floodplain (Vaal), B) channelled valley-bottom, C) seep, D) toe of unchanneled valley-bottom with floodplain depression in the background

Floodplains (HGM Unit 1 and 8)

Two floodplains occur within the project area. The most significant of which is the Vaal River Floodplain. This is a large, well developed and relatively intact floodplain which displays a number of prominent floodplain features. These include a highly sinuous stream channel, large floodplain depressions and an abundance of well vegetated backwaters and meander cut-offs. Situated in the far south-west beyond the expansion area but within the 500 m regulated area is another, smaller, more impacted and un-named floodplain referred to in this report as the Vaal Southern Tributary Floodplain. Both of these systems are classified as FEPA rivers. According to Ollis *et al*. (2013) floodplains are typically located on plains or wide valley floors. They are river features typically characterised by the presence of meander cut-offs, depressions and backwaters. They are, by definition, depositional environments formed by the accumulation of alluvial deposits carried downstream by rivers. Another characteristic of floodplains is that they are typically inundated on average, several times per year, during high flows. Terraces are sometimes present.

Channelled Valley-bottoms (HGM Unit 2)

Channelled valley-bottom wetlands are typically found on valley floors with a clearly defined, finite stream channel and lacks floodplain features, referring specifically to meanders. Channelled valley-bottom wetlands are known to undergo loss of sediment in cases where the wetlands' slope is high and the deposition thereof in cases of low relief. Unchanneled valley-bottom wetlands are typically found on valley floors where the landscape does not allow high energy flows.

Unchannelled Valley-bottoms (HGM Unit 2)

Unchanneled valley-bottom wetlands are typically found on valley-floors where the landscape does not allow high energy flows. Figure 15 presents a diagram of HGM 2, showing the dominant movement of water into, through and out of the system. Unchanneled valley-bottoms are characterised by sediment deposition, a gentle gradient with streamflow generally being spread diffusely across the wetland, ultimately ensuring prolonged saturation levels and high levels of organic matter. The assimilation of toxicants, nitrates and phosphates are usually high for unchanneled valley-bottom wetlands, especially in cases where the valley is fed by sub-surface interflow from slopes. The shallow depths of surface water within this system adds to the degradation of toxic contaminants by means of sunlight penetration.

The Seeps (HGM Unit 3)

Many large seep zones were identified within the project area. Although large portions of these seeps, particularly those on the western side of the Vaal River Floodplain, have been impacted by tillage practice for commercial crop cultivation many, particularly those associated with more incised topography remain relatively intact. These systems contribute significantly to recharge and stream flow regulation of the valley-bottom and floodplain systems. Seeps are wetlands that tend to occur on slopes in situations where the underlying geology and topography facilitates either the discharge of groundwater to the land surface or rain- water to seep down-slope as subsurface interflow (Ollis *et al*. 2013). Either way flows are typically unidirectional and diffuse.

Depressions

Depressions within the project were mainly associated with the Vaal River Floodplain but also occurred in areas to the east of the project area (but within the 500 m regulated rea). The depressions were predominantly intact while those situated in peripheral areas were considerably more impacted by crop cultivation. Depressions are inward draining basins with an enclosed topography that allows for water to accumulate within the system. Depressions, in some cases, are also fed by lateral sub-surface flows in cases where the dominant geology allows for these types of flows. The depressions in the project area were classified as inward draining (endorheic) systems.

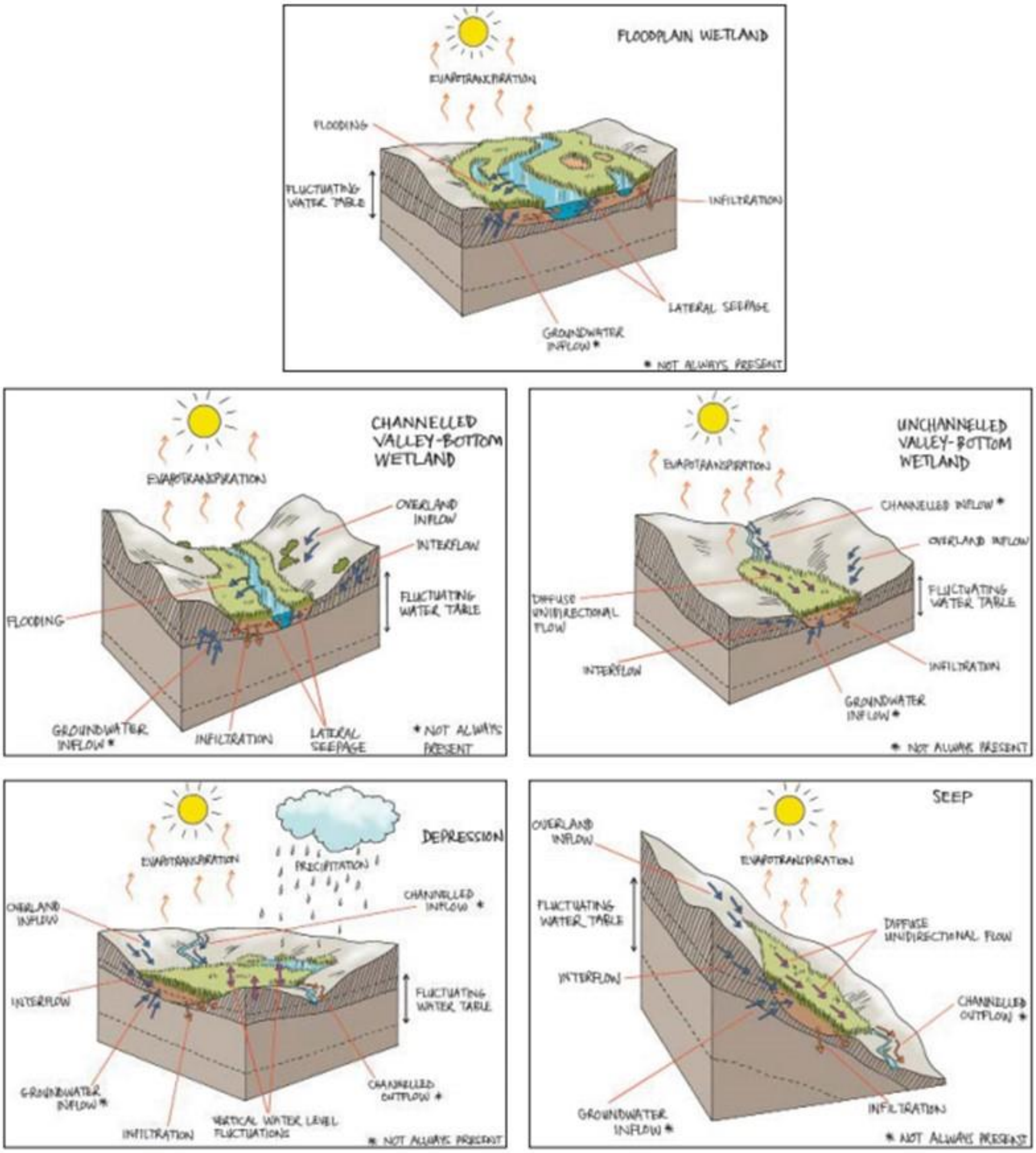


Figure 15: Amalgamated diagram of the HGM types assessed during this study, from SANBI guidelines (Ollis et al. 2013)

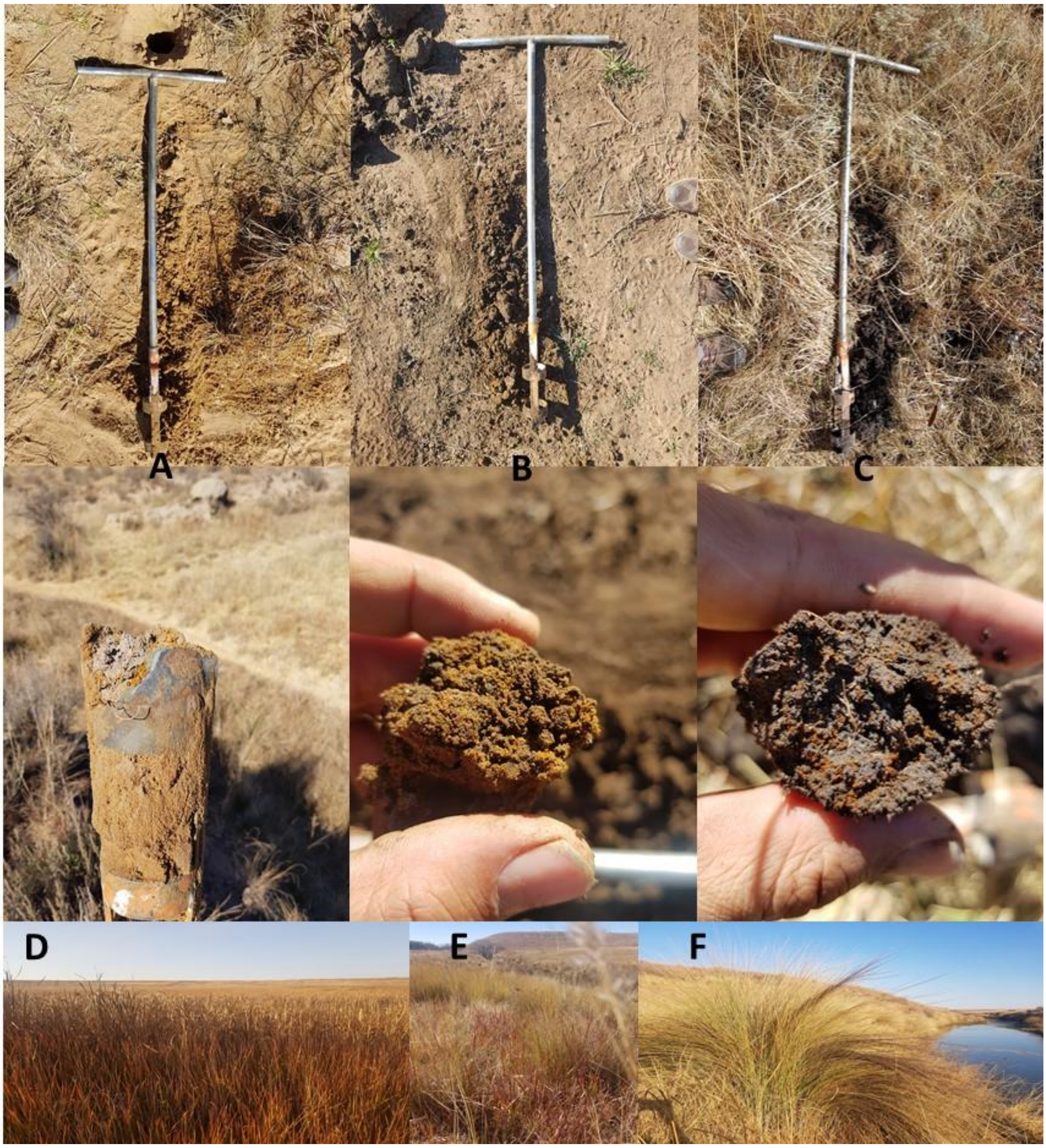


Figure 16: Examples of some of the main wetland indicators used on to delineate the wetlands A) Kroonstad B) Longlands C) Willowbrook soil forms, profile (top) and mottling (bottom), D) Typha capensis, E) Imperata cylindrica F) Scirpoides dioecus

6.1.2 Wetland Ecosystem Services

The ecosystem services provided by the HGM types identified on site were assessed and rated using the WET-EcoServices method (Kotze *et al*. 2009). The summarised results for the HGM groups are shown in Table 10. Overall the Vaal River Floodplain provides by far the highest ecosystem services and was assigned a rating of High. All other HGM units provide Moderately High levels of ecosystem services except for HGM unit 7 which makes a Moderate contribution. In terms of flood attenuation HGM unit 1 is considered most important scoring High, for both its potential to receive floodpeaks (large catchment with steep slopes and high runoff potential) and its efficacy at attenuate them (high channel width, sinuosity, low slope, abundance of depressions and meander cut-offs as well as good vegetation cover). With the exception HGM unit 9 (Moderate), all other wetlands also play an important (Moderately High) role in attenuating stormflows. All of the HGM units provide important streamflow regulation services due to their strong links to groundwater regimes, good vegetation cover and representation of different hydrological zones. However, the two floodplain systems are considered most important in this regard on account of importance and role in transporting significant flow volumes throughout the year.

Table 10: EcoServices being provided by the identified HGM units

Service	HGM Unit								
	1	2	3	4	5	6	7	8	9
Flood attenuation	3.0	2.1	2.4	2.2	2.4	2.0	2.3	2.8	2.0
Streamflow regulation	3.2	2.8	3.0	2.8	2.8	2.7	2.3	3.2	2.7
Sediment trapping	2.8	2.2	2.6	2.6	2.7	2.3	2.4	2.8	2.0
Phosphate assimilation	3.1	2.2	2.6	2.4	2.5	1.8	2.1	2.1	2.7
Nitrate assimilation	3.5	2.5	2.9	2.7	2.7	2.1	2.1	2.6	3.1
Toxicant assimilation	3.2	2.2	2.6	2.4	2.4	2.3	2.3	2.3	2.3
Erosion control	3.4	2.6	2.8	2.3	3.0	2.3	2.3	3.0	2.6
Carbon storage	2.3	1.7	2.0	1.3	1.7	2.0	1.0	2.3	1.0
Biodiversity maintenance	4.0	3.5	3.5	3.5	4.0	3.5	3.5	4.0	3.5
Provisioning of water for human use	3.7	1.8	2.0	1.6	1.6	1.9	1.4	3.7	1.4
Provisioning of harvestable resources	2.8	2.0	2.0	2.0	2.0	2.0	2.2	2.8	2.0
Provisioning of cultivated foods	2.4	2.4	2.4	2.4	2.4	1.0	1.0	1.0	1.0
Cultural heritage	1.8	1.0	1.0	1.0	1.0	1.0	1.0	1.8	1.0
Tourism and recreation	3.3	2.4	2.4	1.6	2.7	1.4	1.4	2.7	2.4
Education and research	2.5	1.8	1.8	1.8	1.8	1.3	1.3	1.8	1.8
Overall	44.7	33.0	35.8	32.5	35.7	29.7	28.5	38.8	31.4
Average	3.0	2.2	2.4	2.2	2.4	2.0	1.9	2.6	2.1
Threats	3.0	3.0	3.0	3.0	3.0	3.0	4.0	4.0	3.0
Opportunities	2.0	2.0	2.0	2.0	2.0	4.0	4.0	2.0	2.0

Except for HGM unit 9 all systems make a Moderately High contribution to sediment trapping. Most of the systems except for those within the existing mining area (HGM 6 and 7) are non-eutrophic, and relatively free of toxicants. Most of the wetlands within the project area also maintain a Moderately High capacity to trap and assimilate any sediments, nutrients (phosphates and nitrates) and toxicants that may enter these systems due to their high saturation levels, and good vegetation cover. These aspects also make these systems effective at controlling erosion particularly in HGM units 1 and 5 where low slopes, high saturation levels and dense vegetation cover create a more depositional environment. Only the two floodplain systems (HGM units 1 and 8) make a meaningful contribution towards carbon storage.

All systems are considered Highly important from a biodiversity maintenance perspective as they are relatively remote, natural and support habitat capable of sustaining resident populations of unique and / or conservation important species (see EIS section for greater detail). Only the two floodplain systems are considered important (High) in terms of direct provision of water for human use and harvestable resources. None of the systems are considered to provide significant cultural benefits. Most of the wetlands within the prospecting area provide good tourism and recreational values.

6.1.3 Wetland Health

The PES for each of the identified wetland groups is presented in Table 11. Overall, most of the wetland systems associated with the Vaal are in a relatively good state and were assessed as Moderately Modified (C). Exceptions included HGM unit 3 which was classified as Largely Natural (B) and HGM unit 4 which was classified as and Largely Modified (D). The two northern HGM units associated with the Witpuntspruit (within the existing mine area) are impacted by the presence of the mine and were rated as Seriously (E) and Moderately Modified respectively.

From a hydrological perspective HGM units 4, 6,7, 8 and 9 are most impacted. HGM units 4,7 and 9 are predominantly impacted by crop cultivation and livestock grazing which has served to decrease water retention time within the wetland (due to decreased infiltration rates from tilling practices such as the ridge and furrow technique) while also increasing erosion risk (due to increased runoff from hardened soil crusts and decreased vegetation cover) respectively. With regards to HGM unit 6, the eastern system is impacted by artificially increased water inputs from mining activities together with the associated water quality implications as evidenced by the significant accumulation of precipitated salts immediately downstream. The western system is predominantly impacted by significant flow impediment caused by a railway crossing. For HGM unit 8 hydrological impacts centre on abstraction to service the many agricultural holdings in its catchment as evidenced by the many upstream dams. The hydrological regime of HGM units 1, 2, and 5 is only Moderately Modified by increased water inputs, increased floodpeaks and decreased surface roughness respectively, while for HGM unit 3 it remains Largely Natural.

Geomorphologically the most impact systems are HGM units 6 and 8 (Largely Modified D) both of which show signs of erosion. The impacts faced by HGM unit 6 (flow impediment along western system due to infilling of railway, increased water inputs from mining on the eastern system and three small earthen dams) have led to the channelization of these wetlands in their downstream reaches (not yet advanced and may easily be ameliorated during the rehabilitation project). The mine water entering the eastern system has been accompanied by the accumulation of salts and sediments which has been deposited in a broad strip along most of the length of the wetland. The sediment regime of HGM unit 8 has been significantly compromised by the presence of several large, upstream dams which have served to trap sediment and concentrate flows at outlet points. This together with low vegetation cover from livestock grazing, high soil erosivity and a steep catchment slope has led to incensement of the channel banks and minor gully formation. The geomorphology of all seeps and depressions (HGM units 4,5,7 and 9) was assessed as Moderately Modified on account of erosional features. The most notable of which occurs in the form of a large gully along a seep in Portion 2, 295 of the northern prospecting area (26°39'53.61"S 30° 5'44.86"E). The geomorphology of the Vaal River Floodplain (HGM unit 1) and associated valley-bottom systems (HGM units 2 and 3) remains in a Largely Natural state.

In terms of vegetation integrity HGM units 1 and 3 were found to be in a Largely Natural state while HGM units 2,5,8,9 were assessed as Moderately Modified on account of minor agricultural related impacts (livestock grazing, old abandoned croplands). Vegetation was most degraded in HGM unit 4 (due to cop cultivation and high grazing pressure) and HGM unit 6 (due to mining infrastructure, shallow and deep flooding by dams / impeding features and areas denuded by sediment deposition and salt precipitation).

Table 11: Summary of the scores for the wetland PES

HGM Unit	Hydrology		Geomorphology		Vegetation		Overall	
	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Vaal								
1	C: Moderately Modified	3.5	B: Largely Natural	1.1	B: Largely Natural	1.8	C: Moderately Modified	2.3
2	C: Moderately Modified	3	B: Largely Natural	1.9	C: Moderately Modified	3.5	C: Moderately Modified	2.9
3	B: Largely Natural	1	B: Largely Natural	1.7	B: Largely Natural	1.6	B: Largely Natural	1.4
4	E: Seriously Modified	6.5	C: Moderately Modified	3.3	D: Largely Modified	4.1	D: Largely Modified	4.9
5	C: Moderately Modified	3.5	C: Moderately Modified	2	C: Moderately Modified	2	C: Moderately Modified	2.6
Witpuntspruit								
6	E: Seriously Modified	6.5	D: Largely Modified	5.5	D: Largely Modified	5.8	E: Seriously Modified	6
7	D: Largely Modified	4	C: Moderately Modified	3.5	C: Moderately Modified	2.9	C: Moderately Modified	3.7
Vaal Southern Tributary								
8	E: Seriously Modified	6	D: Largely Modified	4.8	C: Moderately Modified	2.4	D: Largely Modified	4.6
9	D: Largely Modified	4	C: Moderately Modified	3	C: Moderately Modified	2.4	C: Moderately Modified	3.3

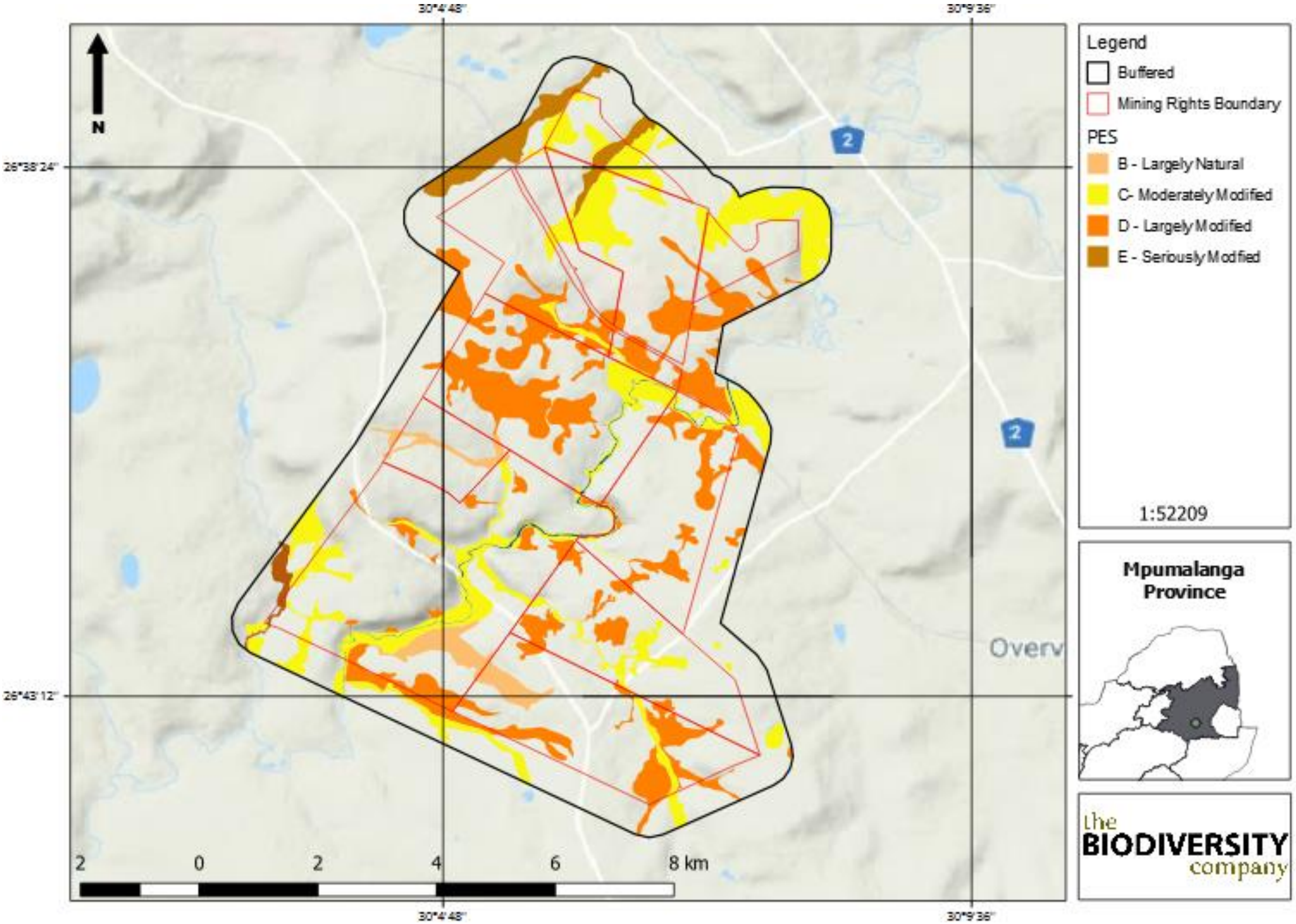


Figure 17: The PES classification for the delineated wetland systems

6.1.4 Ecological Importance and Sensitivity

The wetland EIS assessment was applied to the wetland groups 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 12. Longstanding and widespread coal production within the Mpumalanga grasslands has placed large pressures on its remaining wetland resources. As such all wetlands within this region are considered important, especially considering the upper catchment nature of most of these highveld systems. Indeed, with the exception of seeps (Endangered), all Mesic Highveld Group 4 wetland HGM types are classified as Critically Endangered and Not Protected according to the NFEPA Wetveg Database. On a regional scale the Vaal and its Southern Tributary Floodplains are classified as Phase 1 FEPAs while the Witpuntspruit in the north is classified as a Phase 4 FEPA. A portion of the Vaal River Floodplain within the expansion area is classified as a Wetland FEPA. Wetlands in Portion 3, 295 of the expansion area S102 676PR fall within a protected area according to the MBSP.

At a more local scale the ecological importance and sensitivity of HGM unit 1 scored Very High while most other systems, with the exception of HGM units 4 and 7 (Moderate), scored High. The floodplains, valley-bottom and depression systems within the project area all provide suitable habitat to support a large proportion of the region's wetland dependant species of conservation concern (SCC). Some of the larger and more inaccessible depressions and meander cut-offs within the Vaal River Foodplain (HGM unit 1) provide ideal foraging habitat for both Blue Crane (*Anthropoides paradiseus*) and Grey Crowned Crane (*Balearica regulorum*) and potential breeding habitat for the former. Suitable foraging habitat exists in all HGM units for African Grass-owl and breeding is likely in some of the more remote systems within the prospecting areas. Likewise, the wetland provides foraging habitat for African Marsh Harrier, although suitable breeding habitat in the form of dense reedbeds is lacking. Ideal habitat for Swamp Musk Shrew (*Crocidura mariquensis*) exists in all HGM units. Cape Clawless Otter (*Aonyx capensis*) is likely to occur in the HGM units 1 and 8. Overall, wetlands within the expansion areas are currently not eutrophic, largely intact and retain much of their functionality. Infestations of alien and invasive species is low. As such these wetlands should be considered sensitive and important.

Table 12: The EIS results for the delineated HGM types

Wetland Importance and Sensitivity	HGM 1	HGM 2	HGM 3	HGM 4	HGM 5	HGM 6	HGM 7	HGM 8	HGM 9
Ecological Importance & Sensitivity	3.7	2.7	2.7	2.0	3.0	2.3	1.7	3.0	2.3
Hydrological/Functional Importance	3.0	2.3	2.6	2.3	2.5	2.2	2.1	2.6	2.3
Direct Human Benefits	0.5	1.9	1.9	1.7	1.9	0.5	1.4	2.3	1.6

6.1.5 Buffer Requirements

Graham and de Winnaar (2009) developed guidelines to determine appropriate buffers for the protection of freshwater wetlands from various land use impacts in KwaZulu-Natal. These guidelines have also been considered for this assessment, despite the project being located in Mpumalanga. This method uses a step-wise approach to define an appropriate buffer width based on ecological and biophysical attributes. Figure 18 shows the conceptual buffer delineation model which has been implemented for this project.

According to these guidelines, the minimum buffer width for different wetland types in the presence of "mines" is 175m. This 175m is well-suited for intensive mining activities and is therefore considered to be "generous" for the requirements of a ventilation shaft. Whereas according to the buffer zones guidelines (Macfarlane and Bredin, 2017) 25m and 15m are the minimum recommended buffer zone widths for "mining (worst case)" and "prospecting (all materials)" respectively. This is based on the requirement that the buffer zone must be managed to ensure that the area functions optimally.

According to Desbonnet *et al*. (1994) a buffer width of 200m will enable approximately 90% or greater sediment and pollutant removal, and also be an excellent general wildlife and avian habitat value buffer, likely to support a diverse community. Desbonnet *et al*. prescribed the following maximum buffer widths:

- 100m for wetland species for high intensity impacts from adjacent land uses; and
- 30m for wetland species for low intensity impacts from adjacent land uses.

In addition to the completion of a desktop assessment, further geographic information system (GIS) processing was conducted to better understand the landscape and support the determination of buffer area widths. 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 in order to detect flow accumulations and potential drainage lines, catchment areas and surface flow directions.

As illustrated in Figure 18, the determined buffer width may be modified by taking ecological criteria into consideration (Buffer A) which was considered for this assessment, or for wetlands located within catchments with low EIS ratings (Buffer B) which was implemented for this assessment. Separate buffer calculations were made on the basis of biophysical attributes which included the HGM type, slope and habitat integrity (PES) (Buffer C). The methodology implemented in order to determine the extent of the areas of risk is as follows:

- Updated the desktop wetland shapefiles with the wetlands delineated in field in order to obtain a single wetlands shapefile;
- Standardised the attributes table for the updated wetlands shapefiles using the national wetland classification system nomenclature (i.e. NFEPA wetland nomenclature); and
- Buffers were then assigned systematically to each feature following the proposed process outline presented in Figure 18.

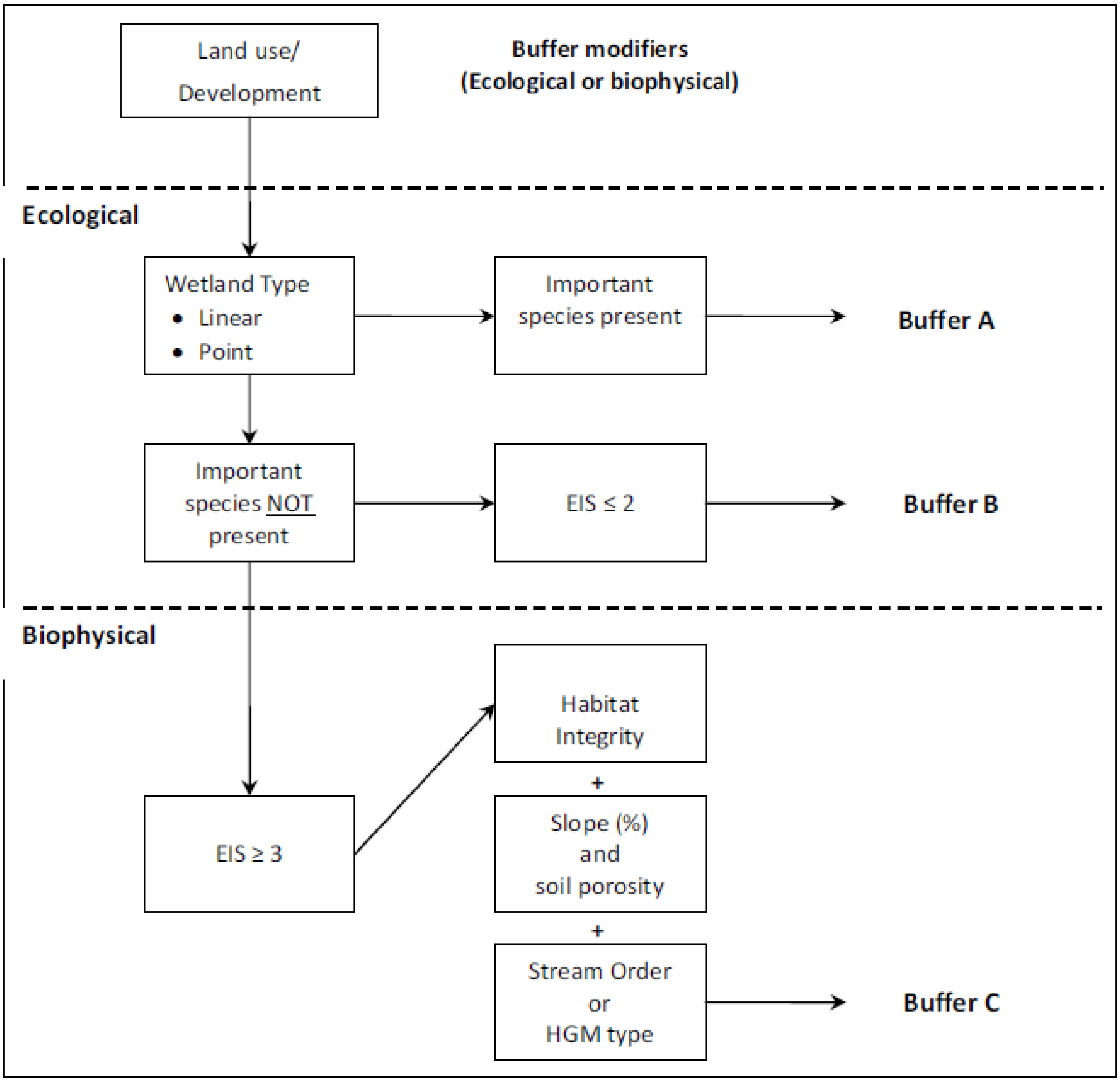


Figure 18: Model for wetland buffer width determination according to land use in KwaZulu-Natal (Source: Graham and de Winnaar, 2009)

Some wetland types are considered to be High Risk areas, whereas other wetland types are considered to be Moderate Risk area. According to Rountree and Kotze (2013) floodplains and valley bottom systems are the most sensitive to flooding, and unchanneled valley bottom systems are the most affected by low flow changes. The following buffer widths, comprising of fixed widths were determined:

- The High Risk areas include the entire extent of the actual wetland areas;
- According to the buffer zones guidelines (Macfarlane and Bredin, 2017) 25m is the minimum recommended buffer zone width for "mining (worst case)". Based on this, a (fixed) 50m buffer has been allocated to all wetland areas and demarcated as a Moderate Risk area. Desbonnet *et al*. (2005) prescribed a maximum buffer width of 30m for wetland species for low intensity impacts from adjacent land uses.

- The Low Risk buffer is the extent of from the 50m Moderate Risk delineation to 100m; and
- Any other area beyond the Low Risk buffer width of 100m would constitute a No Risk area for the ventilation shafts.

6.2 Aquatic Ecosystems

The watercourses associated with Mooiplaats Colliery are located within the Vaal Water Management Area (WMA 5) (NWA, 2016) and the Highveld Lower ecoregion (Dallas, 2007). A total of five sites were selected for the study (Figure 19). These sites were selected to effectively monitor impacts stemming from the activities at the Mooiplaats Colliery. Sites MPU, MPD and MP2 are situated in the Witpuntspruit Sub-Quaternary Reach (SQR) (C11B-1641), while site MV1 is situated in Vaal River SQR (C11B-1693), and site MPW is situated in the Vaal River SQR (C11B-1770). A site description, photographs and GPS coordinates for the sampled river reaches are presented in Table 13.

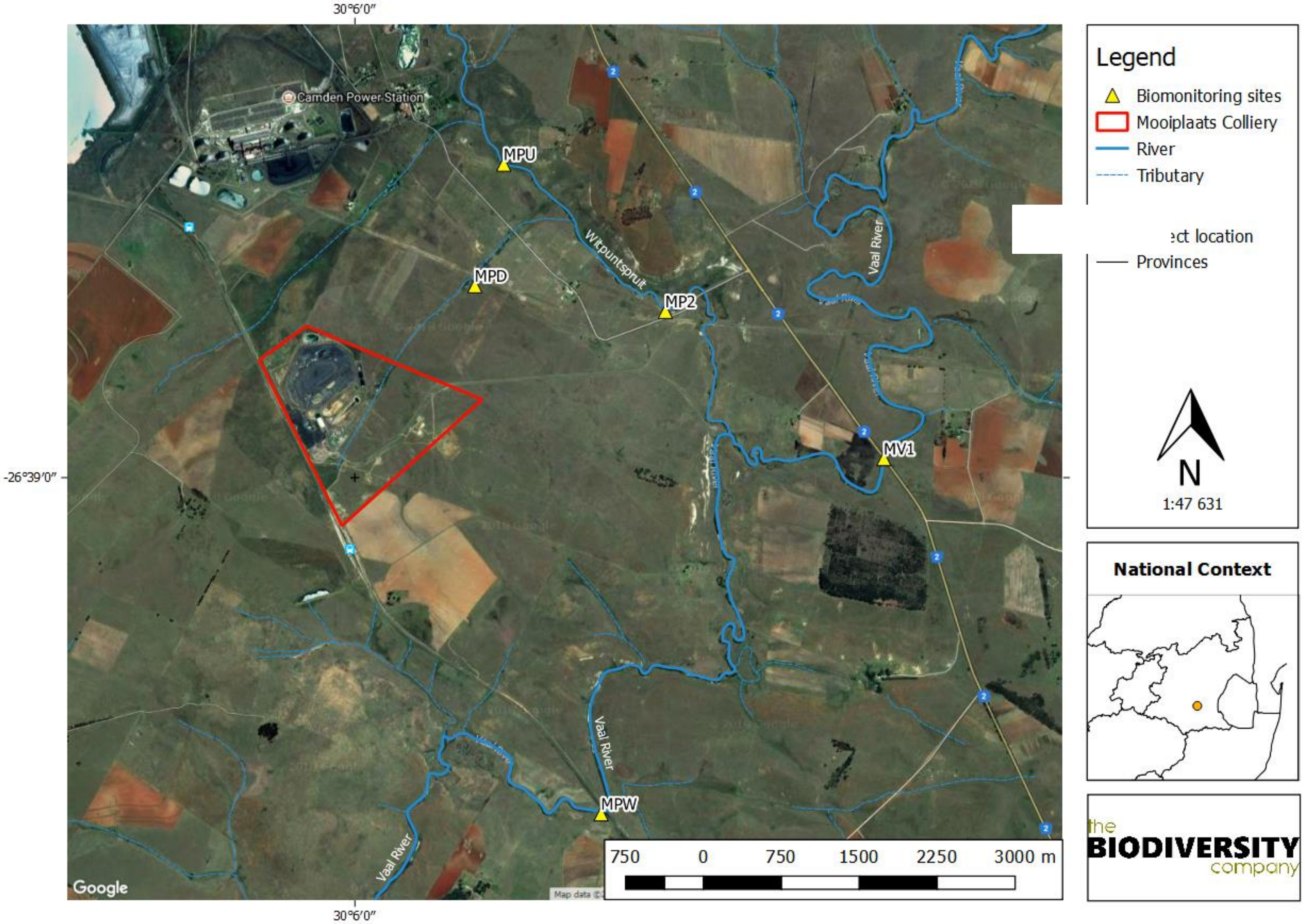
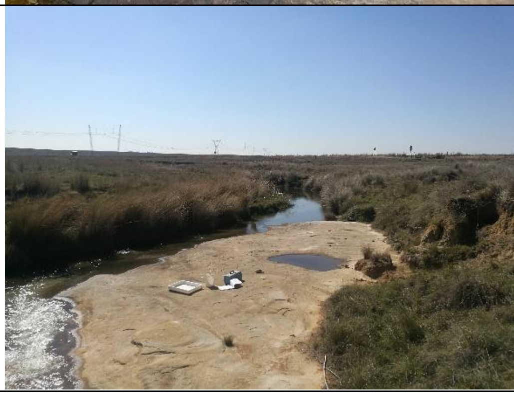
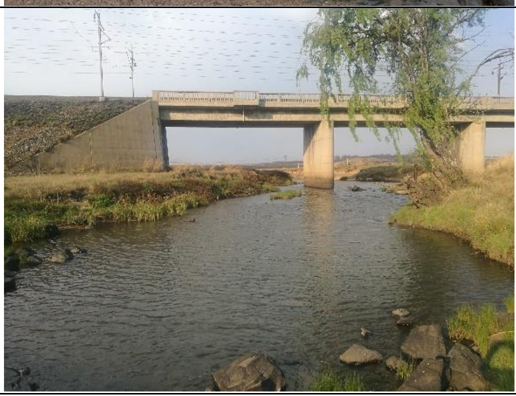
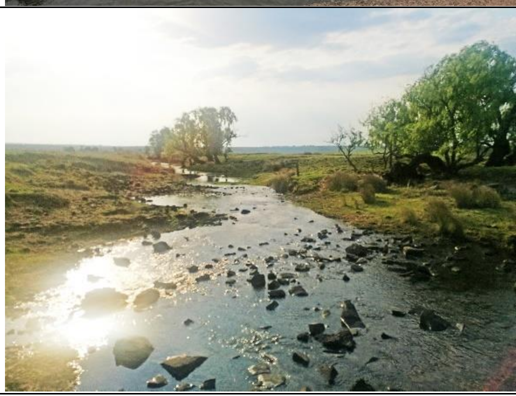


Figure 19: Sampling points for the aquatic assessment

Table 13: Photos, co-ordinates and descriptions for the sites sampled (photos taken: March 2018)

MPU	Upstream	Downstream
High flow		
Low Flow		
GPS	26°37'22.41"S 30° 6'51.69"E	
Site	Site MPU was located upstream of the Mooiplaats Colliery on the Witpuntspruit. The site is further located approximately 1 km downstream of Camden Power Station. The site was characterized by slow flowing waters over sand, mud and stone. Marginal vegetation was abundant in the form of reeds, with moderate amounts of aquatic vegetation present.	
Onsite impacts	A clearing in the channel presumably for vehicle navigation trough the stream was present. Erosion of the riparian and marginal zone by livestock trampling has caused extensive siltation of the system. Black residue was present in the sediment.	
MPD	**Upstream**	**Downstream**
High flow		
Low Flow		
GPS	26°38'0.24"S	

	30° 6'41.62"E	
Site	Site MPD was situated in a dam, approximately 1.4 km downstream of the Mooiplaats Colliery on a tributary of the Witpuntspruit. The site was characterised by standing water.	
Onsite impacts	The dam was subject to trampling by livestock	
MP2	**Upstream**	**Downstream**
High flow		
Low Flow		
GPS	26°38'7.53"S 30° 7'46.81"E	
Site	Site MP2 was located on the Witpuntspruit downstream of the Mooiplaats Colliery and sites MPU and MPD. The site is further located approximately 1 km downstream of Camden Power Station. The site was characterised by slow flowing water over bedrock and sand. Marginal vegetation was abundant.	
Onsite impacts	Instream areas were heavily contaminated from an unknown source, resulting in excessive algae growth smothering all habitat. The water had a blue appearance stemming from the contamination.	

MV1	**Upstream**	**Downstream**
High flow		
Low Flow		
GPS	26°38'54.09"S 30° 9'4.09"E	
Site	Site MV1 was located on the Vaal River upstream of the Witpuntspruit and Mooiplaats Colliery. The site was characterised by slow to fast flowing water over stones, gravel, sand and mud substrate. Marginal and aquatic vegetation were abundant.	
Onsite impacts	Erosion of the riparian area, solid waste disposal, runoff from N2 road bridge, and sedimentation of instream areas.	
MPW	**Upstream**	**Downstream**
High flow		
Low Flow		
GPS	26°40'44.67"S 30° 7'25.61"E	
Site	Site MPW was located on the Vaal River downstream of the Witpuntspruit, site MV1 and Mooiplaats Colliery. The site was characterised by slow to fast flowing water over stones bedrock, gravel, sand and mud substrate. Marginal and aquatic vegetation were abundant.	
Onsite impacts	Small areas of erosion and bank incision. Livestock trampling of riparian areas	

6.2.1 National Freshwater Ecosystem Priority Area Status

Three SQRs were assessed for NFEPAs, including the Witpuntspruit (C11B-1641) and two within the Vaal River system (C11B-1693 and C11B-1770). According to Nel *et al*. (2011), the Witpuntspruit SQR has no freshwater priority areas designated to it. The two Vaal SQRs each have nine NFEPAs listed (Table 14). Furthermore, the Witpuntspruit SQR reach is designated an Upstream Management Area. These areas require management of human activities to prevent degradation of downstream Fish Sanctuaries and Fish Migration Corridors. The Two Vaal SQRs are listed as River FEPA and associated sub-quaternary catchment, meaning "*River FEPAs achieve biodiversity targets for river ecosystems and threatened/near-threatened fish species, and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources".* A notable NFEPA is the fish sanctuary for *Enteromius pallidus* North (*Enteromius* sp. '*pallidus* cf. north') in both Vaal SQRs.

Table 14: NFEPAs listed for SQRs associated with the project area

Type of FEPA map category	Biodiversity features
C11B-1770	
Fish sp.	*Enteromius pallidus* North (*Enteromius* sp. '*pallidus* cf. north')
Number of wetland clusters	2 WetCluster FEPAs
River ecosystem type	Permanent/Seasonal - Highveld - Lower foothill
River ecosystem type	Permanent/Seasonal - Highveld - Lowland river
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Channelled valley-bottom wetland
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Depression
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Floodplain wetland
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Unchannelled valley-bottom wetland
Wetland ecosystem type	Mesic Highveld Grassland Group 8_Depression
C11B-1693	
Fish sp.	*Enteromius pallidus* North (*Enteromius* sp. '*pallidus* cf. north')
Number of wetland clusters	5 WetCluster FEPAs
River ecosystem type	Permanent/Seasonal - Highveld - Lowland river
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Channelled valley-bottom wetland
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Depression
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Floodplain wetland
Wetland ecosystem type	Mesic Highveld Grassland Group 4_Unchannelled valley-bottom wetland
Wetland ecosystem type	Mesic Highveld Grassland Group 8_Depression
Wetland ecosystem type	Mesic Highveld Grassland Group 8_Seep

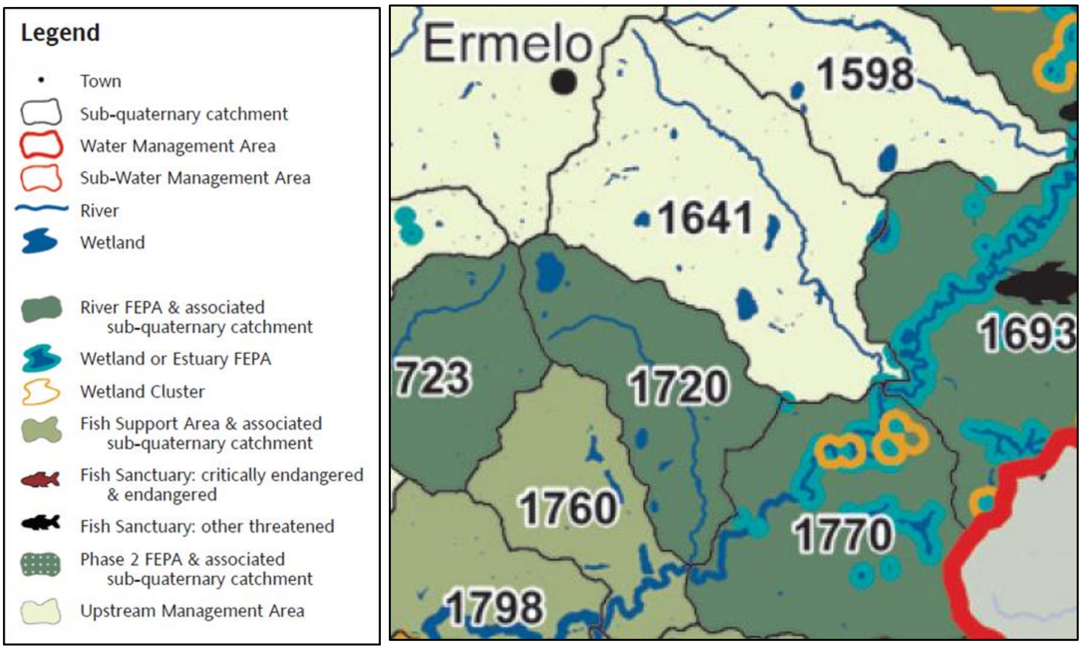


Figure 20: Map illustrating fish and river FEPAs associated with the project area, the project area is represented by the yellow square (Nel et al., 2011)

6.2.2 Desktop Present Ecological Status

Desktop information was obtained from the Department of Water and Sanitation (DWS, 2018) for the three SQRs and is summarised in Table 15. The Ecological Importance (EI) of the reach is classified as high due to the high vertebrate communities (excluding fish), high rarity of fish per secondary catchment, moderate instream migration class, and high riparian-wetland zone migration link class. Biodiversity and species richness are rated as high. Habitat diversity and integrity is classed as moderate. Adverse conditions within the reach are due to bed and channel disturbances, erosion, large dams, abstraction, low water crossings, and irrigation.

The Ecological Sensitivity (ES) is categorised as very high as fish and macroinvertebrate taxa are rated as highly sensitive to flow and physico-chemical water modifications. Wetland-riparian vegetation intolerance to water level changes are rated as low.

Table 15: Present Ecological Status for the three Sub-quaternary reaches (DWS, 2018)

Present Ecological State	Ecological Importance	Ecological Sensitivity	Recommended Ecological Category
Witpuntspruit (C11B-1641)			
Class D	**Moderate**	**Moderate**	**C**
Vaal system (C11B-1693)			
Class C	**High**	**High**	**B**
Vaal (C11B-1770)			
Class C	**High**	**High**	**B**
Anthropogenic Impacts			

The following impacts/activities were identified: Urban runoff from Ermelo, Camden power station, ash dump. Road crossings, Instream dams, agriculture,

6.2.3 *In situ* Water Quality

In situ water quality analyses was conducted at all sites assessed during both the high flow survey (March 2018) (bar site MV1 as in limitations) and low flow survey (October 2018). 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 two surveys are presented in Table 16 and Table 17. Target Water Quality Guidelines (TWQG) are according to DWAF (1996) and the relevant Resource Quality Objectives (RQOs) for the Upper Vaal Resource Units.

Table 16: In situ water quality results for the 2018 low flow survey

Site	pH	Conductivity (µS/cm)	Temperature (°C)
TWQR*	**6.5-9.0**	**<700****	**5-30**
High Flow (March 2018)			
Witpuntspruit			
MPU	6.57	**749**	17.9
MPD	**3.50**	**1840**	18.9
MP2	7.69	**1560**	19.0
Vaal River			
MV1	P.M		
MPW	7.37	209	21.5

Table 17: In situ water quality results for the 2018 high flow survey

Site	pH	Conductivity (µS/cm)	Dissolved Oxygen (mg/l)	Temperature (°C)
TWQR*	**6.5-9.0**	**<700****	**>6.00**	**5-30**
Low Flow (October 2018)				
Witpuntspruit				
MPU	**6.3**	**1263**	5.6	21.4
MPD	**3.3**	**7220**	6.8	19.3
MP2	8.1	**1144**	6.1	18.3
Vaal River				
MV1	7.1	210.0	6.6	19.8
MPW	8.3	285.0	6.5	21.9
**Resource Quality Objective water quality guideline				

According to the high flow results, pH levels ranged from 3.50 at site MPD to 7.69 at site MP2. A single site fell outside the recommended guideline range (MPD), downstream of the Mooiplaats Colliery. Low flow results presented similar findings as illustrated in Figure 21, however, the pH at site MPU of 6.3 fell below threshold effect levels. Figure 21 further presents spatial trends within the system. The pH levels within the Vaal River sites remained within TWQR. The Witpuntspruit is contributing to the increase in pH of the Vaal system, as illustrated by the low flow findings (Figure 21). The pH levels within the Witpuntspruit would present adverse conditions to local aquatic biota and expect to limit diversity and abundances at chronic levels.

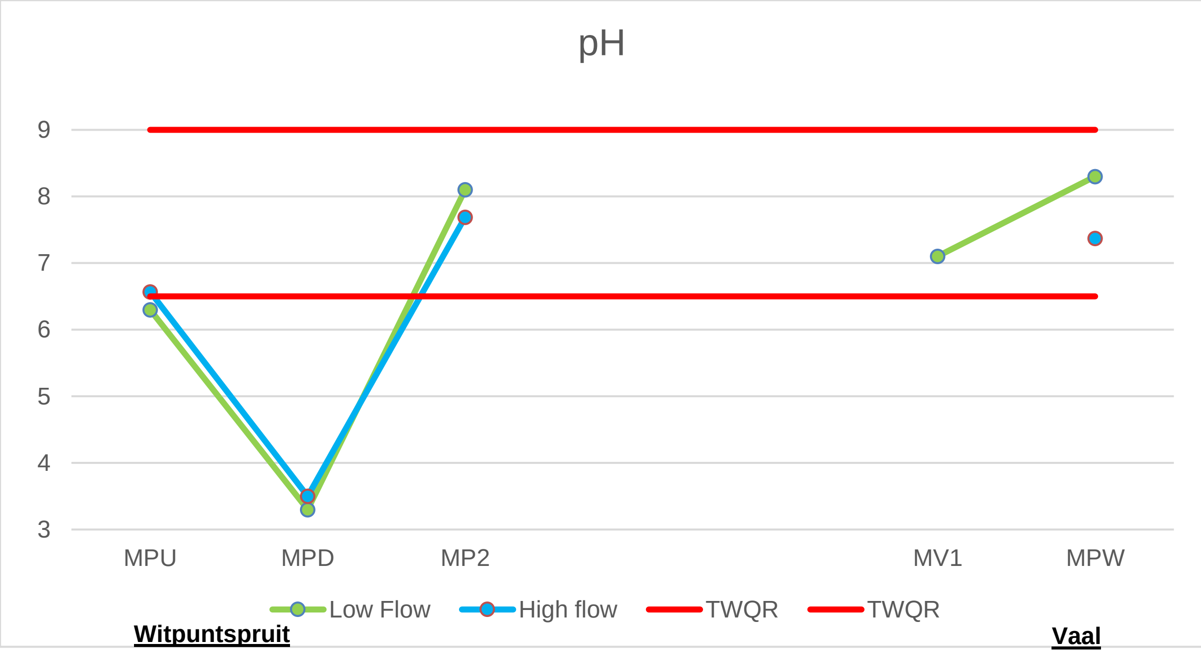


Figure 21: Spatial and temporal trends for pH levels of the aquatic systems

Electrical Conductivity (EC) levels ranged from 749 µS/cm to1840 µS/cm on the Witpuntspruit at sites MPU and MPD respectively during the high flow survey. An increase in dissolved solids was observed during the low flow survey, with dissolved solids ranging from 1144 µS/cm at site MP2 and 7220 µS/cm at site MPD. The lack of connectivity between MPD and the Witpuntspruit reduced the influx of dissolved solids stemming from the Mooiplaats tributary. All sites on the Witpuntspruit during both high and low flow surveys exceeded TWQRs for the system. As illustrated by Figure 22, spatial trends of the Witpuntspruit indicate the Mooiplaats Colliery is contributing to increased EC levels of the Witpuntspruit. The dissolved solid levels within the Vaal River remained within TWQR during both surveys, however, the Witpuntspruit is contributing an increase of 25% as illustrated by Figure 23. The elevated EC levels within the Witpuntspruit would present adverse conditions to local aquatic biota, and limit diversity and abundances.

The Dissolved Oxygen levels within all sites assessed fell within TWQR. The DO levels ranged from 5.6 mg/l at site MPU to 6.8 mg/l at MPD. The DO levels would not be expected to have a limiting effect on local aquatic biota.

Water temperatures recorded during both the high and low flow surveys fell within expected ranges for the region and would not present adverse conditions to local aquatic biota.

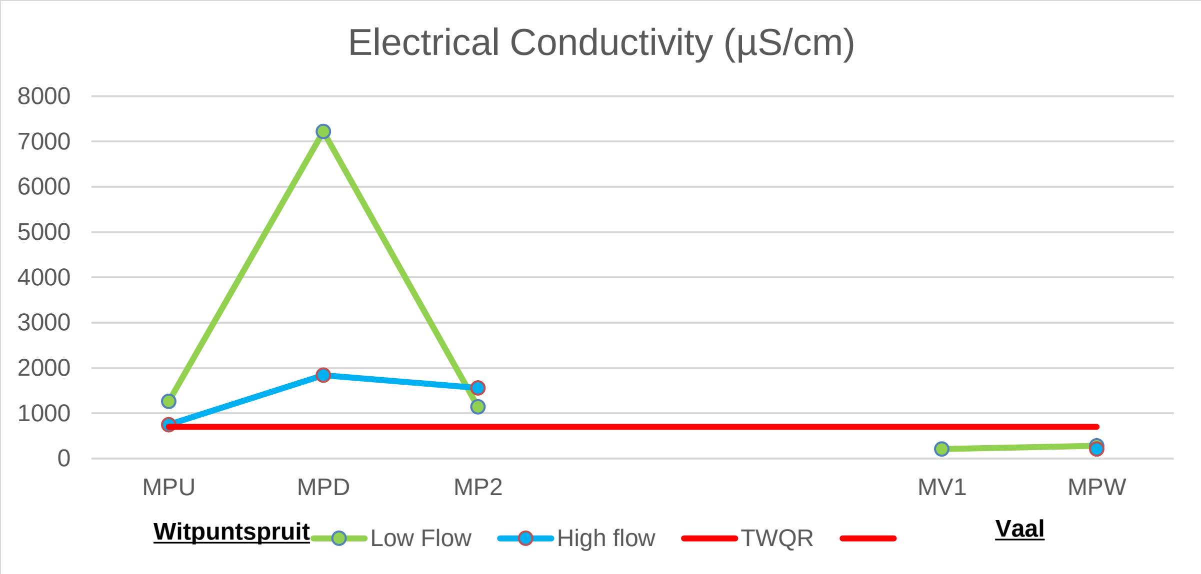


Figure 22: Spatial and temporal trends for Conductivity levels in the tributary (TWQR- Target Water Quality Range, WUL- Water Use License)

Figure 23: Illustration of likely salts below the Mooiplaats operation, upstream of site MPD (Google Earth Imagery, 2017; 26° 38.566'S 30° 6.115'E)

Figure 24: Illustration of salts below the Mooiplaats operation, upstream of site MPD (Google Earth Imagery, 2017; 26° 38.192'S 30° 6.419'E)

Figure 25: Illustration of salts below the Mooiplaats operation, upstream of site MPD (Photo taken, October 2018; 26° 38.192'S 30° 6.419'E)

6.2.4 Habitat Assessment

6.2.4.1 Intermediate Habitat Integrity Assessment

The results for the instream and riparian habitat integrity assessment for the Witpuntspruit and Vaal River are presented in Table 18 and

Table 19 respectively. The reaches include 5 km of each system associated with the sampling points assessed during the study.

Table 18: Results for the Witpuntspruit habitat integrity assessment

Instream	Average	Score
Water abstraction	14	7,84
Flow modification	13	6,76
Bed modification	16	8,32
Channel modification	16	8,32
Water quality	18	10,08
Inundation	7	2,8
Exotic macrophytes	5	1,8
Exotic fauna	4	1,28
Solid waste disposal	3	0,72
Total Instream		**52.08**
Category		**D**
Riparian	**Average**	**Score**
Indigenous vegetation removal	12	6,24
Exotic vegetation encroachment	9	4,32
Bank erosion	11	6,16
Channel modification	13	6,24
Water abstraction	7	3,64
Inundation	4	1,76
Flow modification	11	5,28
Water quality	12	6,24
Total Riparian		**60.12**
Category		**C**

Table 19: Results for the Vaal River habitat integrity assessment

Check table header across page	Average	Score
Water abstraction	13	7,28
Flow modification	11	5,72
Bed modification	7	3,64
Channel modification	10	5,2

Check table header across page	Average	Score
Water quality	7	3,92
Inundation	8	3,2
Exotic macrophytes	12	4,32
Exotic fauna	9	2,88
Solid waste disposal	5	1,2
Total Instream		**62.64**
Category		**C**
Riparian	**Average**	**Score**
Indigenous vegetation removal	9	4,68
Exotic vegetation encroachment	9	4,32
Bank erosion	12	6,72
Channel modification	11	5,28
Water abstraction	12	6,24
Inundation	9	3,96
Flow modification	10	4,8
Water quality	7	3,64
Total Riparian		**60.36**
Category		**C**

According to the instream habitat index the Witpuntspruit reach was classed as largely modified (class D): A large loss of natural habitat, biota and basic ecosystem functions has occurred. Modifications are associated with channel and bed erosion, resulting in channelized deep reaches of the system. Additional modifications included water quality and flow modifications, predominantly due to influx of pollutants stemming from urban runoff, mining activities, and Camden Power Station. Flow modifications stem from abstraction, and the presence of an artificial wetland located upstream of the project area (Figure 26).

According to the IHIA results the Witpuntspruit riparian habitat integrity in the reach was rated as class C, or moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged. Loss of riparian habitat is associated with over grazing and agricultural activities. Furthermore, the channel modifications within the system has reduced lateral movement of water within the reach.

According to the IHIA results the instream and riparian habitat integrity of the Vaal Reach were rated as Class C, or Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged. Modifications include bank and channel erosion (Figure 27), flow modification due to several instream structures including weirs and low water crossings. Several exotic macrophytes were observed within the reach (e.g. parrots feather, course oxygen weed and watercress), inundating instream and marginal vegetation.

Figure 26: Aerial imagery illustrating impacts within the reach; artificial wetland upstream of site MPU (Google Earth 2018)

Figure 27: Illustration of bank erosion at site MV1 (Taken: March 2018)

6.2.5 Aquatic Macroinvertebrates

6.2.5.1 Invertebrate Habitat and Biotope Assessments

A biotope rating of available habitat was conducted at each site assessed to determine the suitability of habitat to macroinvertebrate communities. The rivers within the project area were predominantly classed as lower foothills (Table 20). Each geoclass has different weightings for the various biotopes according to importance value (Table 21). The categories were calculated according to the biotope rating assessment as applied in Tate and Husted (2015). The results of the biotope assessment are presented in Table 22 and Table 23. A rating system of 0 to 5 was applied, 0 being not available.

Table 20: Geoclass of rivers within the project area

Zonation	Sites
Class E: Lower Foothills	MPU, MP2
Class F: Lowland River	MV1, MPW

Table 21: Biotope weightings for lower foothill geoclass

Biotope	Lower Foothills	Lowland River
Stones in current (SIC)	18.0	15.0
Stones out of current (SOOC)	12.0	12.0
Bedrock	3.0	20..
Aquatic vegetation	1.0	2.5
Marginal vegetation in current	2.0	20
Marginal vegetation out of current	2.0	20.0
Gravel	4.0	0.5
Sand	2.0	4.0
Mud	1.0	1.5

Table 22: Biotope scores at each site during the survey (March 2018)

Biotope	MPU	MP2	MV1	MPW
Stones in current	0	0.5	3	4
Stones out of current	1	0	3	4
Bedrock	0	3	2	3
Aquatic Vegetation	2.5	2	1	4
Marginal Vegetation in Current	0	3	3.5	2
Marginal Vegetation Out of Current	4	2	3	3
Gravel	0	0	3	3
Sand	1	1.5	2	2
Mud	2.5	0.5	2	2
Biotope Score	11	12.5	22.5	27

Weighted Biotope Score (%)	24	26	53	63
Biotope Category (Tate and Husted, 2015)	**F**	**F**	**C**	**B**

Table 23: Biotope scores at each site during the survey (October 2018)

Biotope	MPU	MP2	MV1	MPW
Stones in current	0	1	3	4
Stones out of current	0	0	3	2,5
Bedrock	0	3	2	2
Aquatic Vegetation	3	0	2,5	3
Marginal Vegetation in Current	1	2	2	3
Marginal Vegetation Out of Current	3,5	3,5	4	3
Gravel	0	0	2	2
Sand	0	0	1	2
Mud	1	2	3	2
Biotope Score	8.6	11.5	22.5	23.5
Weighted Biotope Score (%)	6	18	50	56
Biotope Category (Tate and Husted, 2015)	**F**	**F**	**C**	**B**

The Witpuntspruit sites (MPU and MP2) assessed in this study were assigned a biotope category of class F, indicating seriously limited habitat availability for aquatic macroinvertebrates, while the Vaal River sites (MV1 and MPW) were assigned a class C and class B, respectively indicating diverse habitat availability within the Vaal system.

It was noted in the field that MP2 was particularly modified with extensive algal growth, limiting habitat availability (Figure 28). The site had a strong sulphur odour.

Figure 28: Excessive algal growth at site MP2. Photographed 16 March 2018

6.2.5.2 South African Scoring System (version 5)

The aquatic macroinvertebrate results for the study are presented in Table 24.

Table 24: Macroinvertebrate assessment results recorded during the survey

Site	MPU	MP2	MV1	MPW
River	**Witpuntspruit**		**Vaal River**	
High Flow (March 2018)				
SASS Score	81	73	122	186
No. of Taxa	17	17	26	35
ASPT*	4.8	4.3	4.7	5.3
Category (Dallas, 2007)	**B**	**C**	**A**	**A**
Low Flow (October 2018)				
SASS Score	116	79	160	159
No. of Taxa	22	15	32	32
ASPT*	5.3	5.2	5.0	5.0
Category (Dallas, 2007)	**B**	**C**	**A**	**A**

*ASPT: Average score per taxon
**Highveld-Lower Ecoregion

Based on the Average Score Per Taxon (ASPT) the aquatic macroinvertebrate communities for the sampled reaches comprised primarily of tolerant taxa (Intolerance Rating < 5) during the high flow study, while predominantly moderately tolerant taxa were collected during the low flow study (Intolerance Rating 6 - 10).

The total sensitivity scores from the high flow survey ranged from 73 at site MP2, to 186 at site MPW, with ASPTs ranging from 4.3 at MP2 to 5.3 at site MPW. Ecological categories on the Witpuntspruit ranged from class B to class C at sites MPU to MP2 respectively. The ecological categories of the Vaal River were rated as class A at both sites, with increase of total sensitivity of 122 to 186 from the upstream MV1 site to MPW.

Low flow results indicated increased total sensitivity scores at all sites assessed, ranging from 79 at site MP2 to 160 at site MV1. Ecological categories at sites MV1 and MPW were rated as class A. Sites on the Witpuntspruit ranged from class B at MPU to a class C at MP2. Figure 29 illustrates temporal trends for total sensitivity scores between the 2012 and 2018 high flow surveys. Results indicate an improved macroinvertebrate community at site MP2 and MPW. The trends indicate that a decrease in sensitivity score between sites MPU and MP2 persists, however, poor habitat diversity at site MP2 contributes to the lower ecological category of the site. This trend is also reflected in the ASPT of the Witpuntspruit (Figure 30). The results for the Vaal River system indicate an improved total sensitivity score at the downstream MPW site between 2012 and 2018, and an increase of ASPT between the upstream and downstream sites during both 2012 and 2018 surveys.

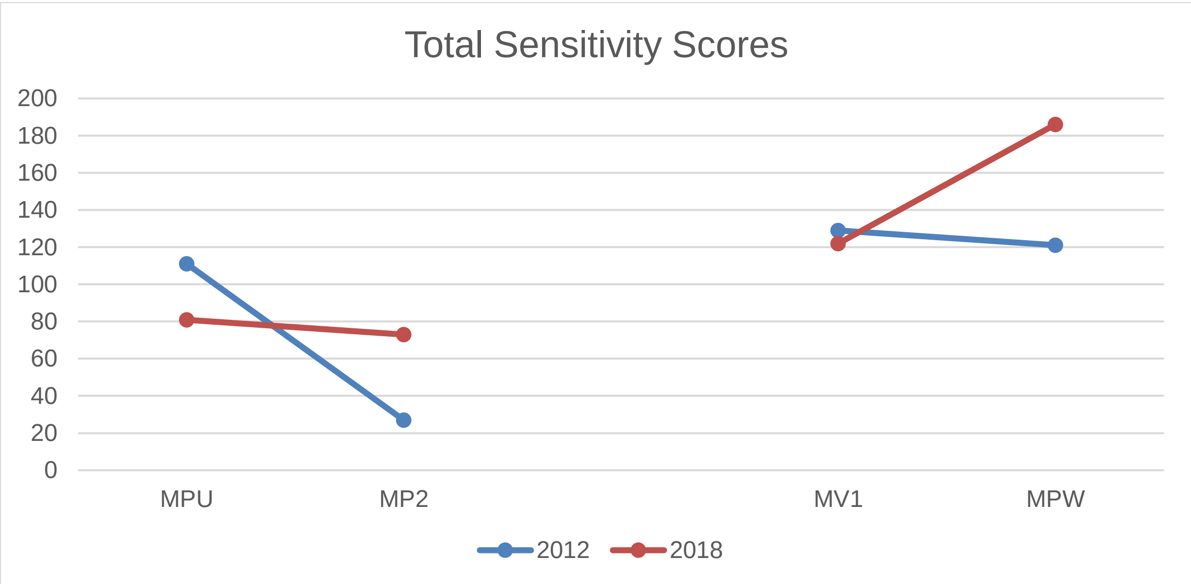


Figure 29: High flow Temporal trends of total sensitivity scores between 2012 and 2018

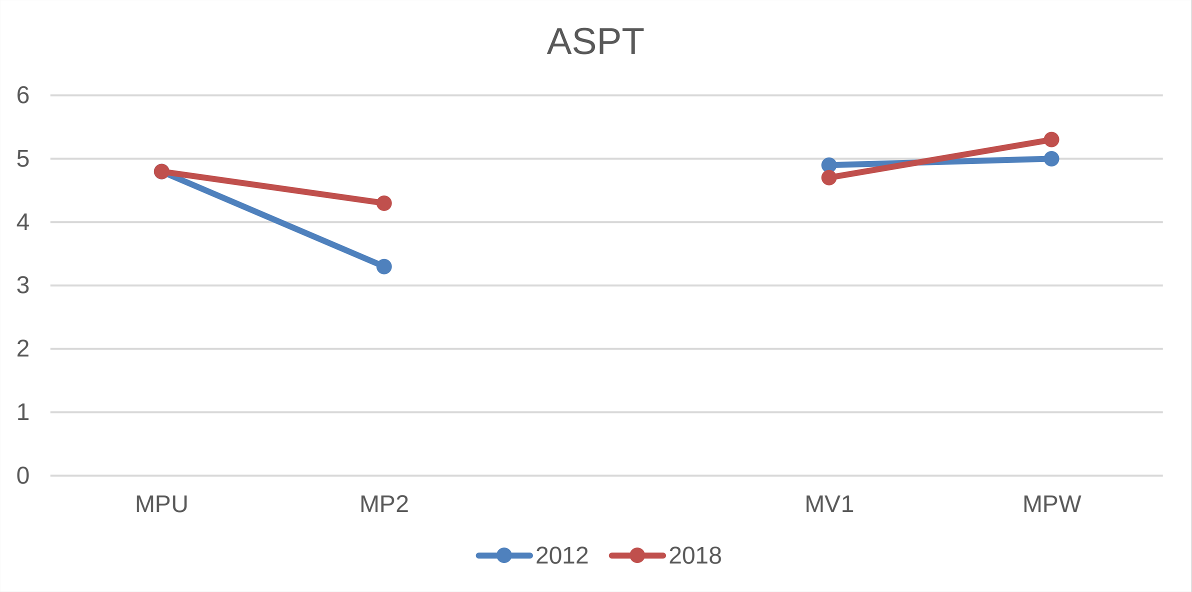


Figure 30: High flow temporal trends for ASPT between 2012 and 2018

6.2.5.3 Macroinvertebrate Response Assessment Index

The Macroinvertebrate Response Assessment Index (MIRAI) methodology was conducted according to Thirion, (2007). Data collected from the SASS5 method was applied to the MIRAI model. The MIRAI model provides a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community (assemblage) from the reference condition (unmodified river). Results for the reaches assessed are presented in Table 25 to Table 26.

Table 25: MIRAI Score for the Witpuntspruit River reach (2018)

Invertebrate Metric Group	Score
Flow Modifications	66,1
Habitat	78,2
Water Quality	56,7
Ecological Score	**66.6**
Category	**C**

Table 26: MIRAI Score for the Vaal River reach (2018)

Invertebrate Metric Group	Score
Flow Modifications	82,0
Habitat	83,1
Water Quality	77,0
Ecological Score	**80.6**
Category	**C/B**

The MIRAI results for the Witpuntspruit indicates the reach is moderately modified (class C). The driver predominantly contributing to the modified state is water quality impairment and followed by flow modifications within the reach.

The results for the Vaal River reach indicate that the system is in a moderately modified to largely natural state. Water quality was identified as a driver responsible for modifying local aquatic biota in the system. Several sensitive taxa were notable absent from the reach, including Psephenidae, Heptageniidae, and Perlidae.

6.2.6 Fish Assessment

6.2.6.1 Expected Species and Fish Collected

Fish sampling was conducted at sites MPU, MV1 and MPW. Fish were collected using electrofishing techniques in all available biotopes.

Biotopes sampled in the Witpuntspruit were predominantly slow flowing waters over sand and mud substrates. Cover features included marginal and aquatic vegetation. Two (2) of the six expected fish species were collected in the Witpuntspruit at site MPU (Table 27). No species of conservation importance were collected. The results from the fish assessment indicate that the community structure of the sampled Witpuntspruit reach was in a modified condition, due to the absence of 33.3% of the fish species from reference conditions during the high flow assessment. Similar fish community structures were observed during the low flow assessment.

Biotopes sampled in the Vaal River were predominantly slow to fast flowing water over bedrock, stones, gravel, sand and mud biotopes. Cover features included stones, bedrock, marginal vegetation, tree stumps and undercut banks. Seven (7) of the 11 expected fish species were collected in the Vaal River at the upstream site MV1 during the high flow survey, and four during the low flow survey. A single alien invasive fish species *Cyprinus carpio* (Common Carp) was collected at site MV1 during the high flow survey. Nine (9) of the 11 expected fish species were collected at the downstream site MPW during the high flow survey, along with a single alien invasive fish species *Micropterus salmoides* (Largemouth Bass). Seven of the 11 expected species were collected during the low flow survey, with *Austroglanis sclateri* and *Clarias gariepinus* being absent from the later survey. Habitat was preferable for the expected fish species at the downstream site MPW with increased flows and higher diversity compared to site MV1. This resulted in a greater fish diversity downstream. A particularly uncommon species *Austroglanis sclateri* (Rock Catfish) was recorded at the downstream site during the high flow survey. The results from the fish assessment indicated that the community structure of the sampled Vaal River reaches were in a largely unmodified condition, due to the absence of 36% (MV1) and 19% (MPW) of the fish species from reference conditions. A single species of conservational concern was collected during the survey (*Enteromius* sp. '*pallidus* cf. north'), which is currently undergoing taxonomical revision. As the species is yet undescribed, a cautious criterion of Critically Endangered is designated to the species. Illustrations of fish collected during the survey are presented in Table 28.

According to the Frequency of Occurrence (FROC), the most common species within he project area was *Pseudocrenilabrus philander* and *E. paludinosus,* with 100% occurrence at all sites assessed. *P. philander* is considered tolerant to flow and physico-chemical modifications, while *E. paludinosus* is considered moderately intolerant.

Table 27: Fish community assessment for the 2018 study

Scientific name	High Flow (March 2018)			Low Flow (October 2018)				Sensitivity	
	MPU	MV1	MPW	MPU	MV1	MPW	FROC (%)	No-flow	Phys-chem
Austroglanis sclateri	N/E	-	✓	-	-	-	0.8	3.2	2.6
Clarias gariepinus	-	-	✓	-	-	-	0.8	1.7	1.0
Cyprinus carpio	-	✓	-	-	-	-	0.8	N/A	N/A
Enteromius anoplus	-	✓	✓	-	✓	✓	3.3	2.3	2.6
Enteromius sp. 'pallidus cf. north'	-	✓	✓	-	-	✓	2.5	3.4	
Enteromius paludinosus	✓	✓	✓	✓	✓	✓	5	2.3	1.8
Labeo capensis	N/E	✓	✓	-	-	✓	2.5	3.5	2.8
Labeo umbratus	N/E	-	-	-	-	-	0	2.7	1.6
Labeobarbus aeneus	N/E	✓	✓	-	-	✓	2.5	3.3	2.5
Labeobarbus kimberleyensis	N/E	-	-	-	-	-	0	3.8	3.6
Micropterus salmoides	-	-	✓	-	-	✓	1.7	N/A	N/A
Pseudocrenilabrus philander	✓	✓	✓	✓	✓	✓	5	1.0	1.4
Tilapia sparrmanii	-	✓	✓	-	✓	✓	3.3	0.9	1.4
Total Indigenous Species Recorded	2	7	9	2	4	7			
Total Alien Invasive Species Recorded	0	1	1	0	0	1			
FROC- Frequency of Occurrence (0 - absent; 5 - present at all sites)									

Table 28: Photographs of fish species collected during the 2018 high flow survey

Austroglanis sclateri

Clarias gariepinus

Cyprinus carpio (Exotic)

Enteromius anoplus

Enteromius sp. 'pallidus cf. north'

Enteromius paludinosus

Labeobarbus aeneus

Labeo capensis

Micropterus salmoides (Exotic)

Pseudocrenilabrus philander

Tilapia sparrmanii

6.2.6.2 Fish Response Assessment Index

The results of the FRAI assessment for the reaches assessed are presented in Table 29 and Table 30.

The results indicate that the Witpuntspruit fish community was moderately modified during the survey. The modified fish community is attributed to flow modifications within the reach, and the absence of habitat features such as cobbles. Should additional sampling be conducted within the reach, it is likely that fish would be collected.

The results for the Vaal River fish community indicates a moderately modified to largely natural fish assemblage. Several expected species were absent within the reach, however, their expected Frequency of Occurrence is low.

Table 29: Fish Response Assessment Index for the Witpuntspruit

FRAI% (Automated)	63,6
EC FRAI	C

Table 30: Fish Response Assessment Index for the Vaal River

FRAI% (Automated)	79,5
EC FRAI	B/C

6.2.7 Present Ecological State

The Present Ecological State of each reach assessed for the study is presented in Table 31 and Table 32. The findings of the study were based on two surveys, of which time constraints limit sampling effort within the reaches, and therefore the confidence of the findings are moderate.

The results indicate that the Witpuntspruit reach was in a moderately modified state during the survey (Table 31). This is attributed to the water quality and flow modifications within the reach, and furthermore modifications to the riparian zone due to agriculture and over grazing. The results indicate that the Vaal River reach was in a moderately modified state during the survey (Table 32). A largely natural to moderately modified aquatic biota was observed during the survey, however, modifications to habitat (riparian and instream) were moderate to large. Bank erosion and channel modifications were observed during the study.

Table 31: The Present Ecological Status of the Witpuntspruit reach

Category	Score	Ecological Category
Riparian	60.12	C
Macroinvertebrate	66.6	C
Fish	63.6	C
EcoStatus	C	

Table 32: The Present Ecological Status of the Vaal River reach

Category	Score	Ecological Category
Riparian	60.36	**C**
Macroinvertebrate	80.6	**C/B**
Fish	79.5	**C/B**
EcoStatus	**C**	

7 Underground Mining Risk Assessment

The risk assessment has been undertaken for the proposed underground mining project. The risk assessment has also been undertaken for the proposed sinking of two ventilation shafts. The location of the shafts is not yet known, and it is assumed that findings from the wetland assessment will inform the selection of the shaft locations. Due to the nature of the proposed project, the mining will take place directly below the delineated wetland areas as presented in Figure 10.

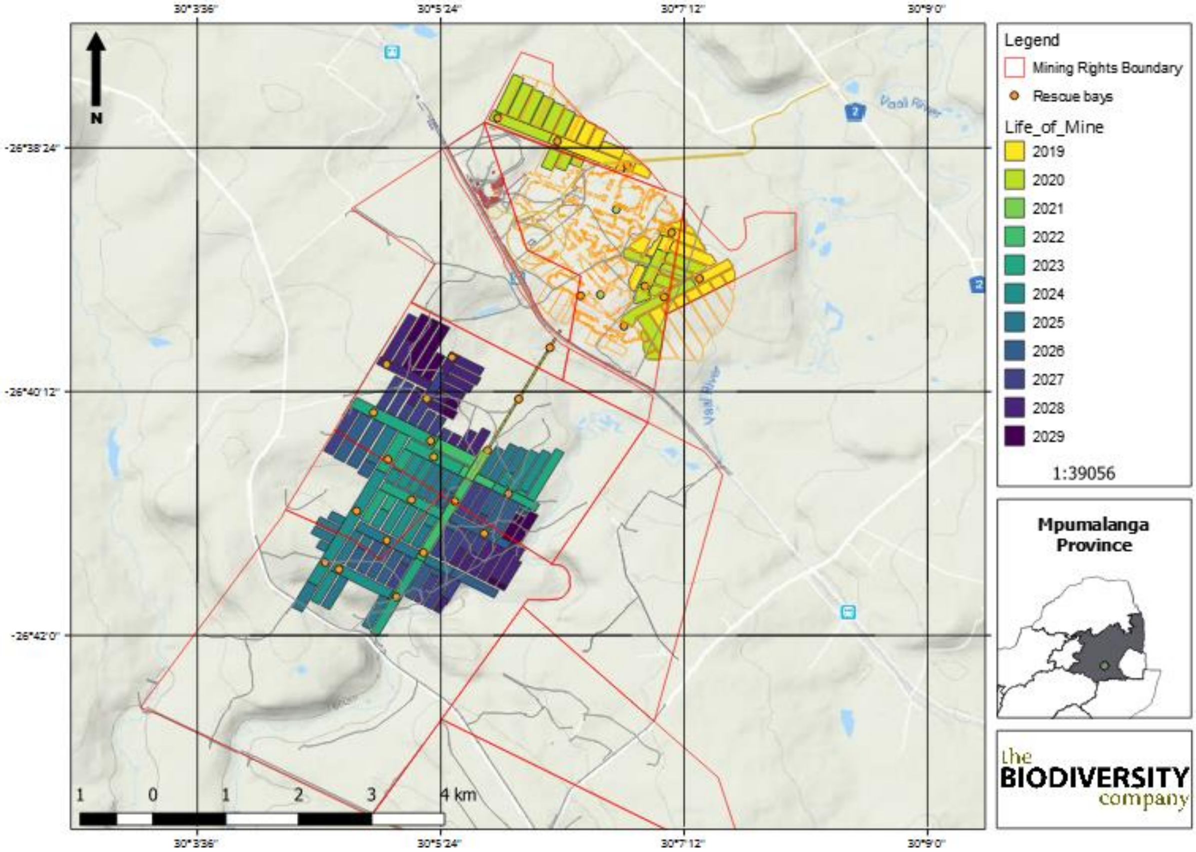


Figure 31: The extent of underground mining areas for the risk assessment

7.1 Potential Impacts

The potential impacts arising from the undermining of the wetlands are summarised and provided below (Table 33).

Underground mining generally has lower environmental impacts than opencast mining. Nonetheless, underground mining can still have significant impacts on sub-surface water and water flow, and therefore still poses threats to wetlands systems above ground. It has been assumed that access to the proposed expansion area will be from the existing mining areas, with no surface access points considered. Mining depths are not yet known, but for the purposes of this assessment it has been assumed that subsidence will be unlikely across the project area.

Table 33: Impacts assessed for the proposed project

Activity	Aspect	Impact
Andrew Husted (Pr Sci Nat 400213/11)		
Construction phase	Blasting (dislodging of rock)	Alteration to surface flows Impaired water quality
	Fractures in bedrock	
	Disruption (draining of aquifers)	
	Operation of machinery, vehicles and equipment	
Operation phase	Blasting (dislodging of rock)	Alteration to surface flows Impaired water quality
	Fractures in bedrock	
	Disruption (draining of aquifers)	
	Operation of machinery, vehicles and equipment	
Decommission phase	Pollution of water resources	Alteration to surface flows Impaired water quality
	Decant of mine workings	
	Operation of machinery, vehicles and equipment	

Table 34: DWS Risk Impact Matrix for the proposed project

Severity								
Aspect	**Flow Regime**	**Water Quality**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**
Construction Phase								
Blasting (dislodging of rock)	2	2	1	2	1.75	3	4	8.75
Fractures in bedrock	2	1	2	2	1.75	3	4	8.75
Disruption (draining of aquifers)	3	1	2	1	1.75	3	4	8.75
Operation of machinery, vehicles and equipment	**1**	**2**	**2**	**2**	1.75	**2**	2	5.75
Operational Phase								
Blasting (dislodging of rock)	3	2	3	3	2.75	3	2	7.75
Fractures in bedrock	3	2	3	3	2.75	3	2	7.75
Disruption (draining of aquifers)	4	2	3	3	3	3	2	8
Operation of machinery, vehicles and equipment	**1**	**2**	**2**	**2**	1.75	**2**	2	5.75
Closure Phase								
Pollution of water resources	1	4	2	2	2.25	3	5	10.25
Management of water quality	**1**	**2**	**2**	**2**	1.75	**2**	**5**	8.75
Operation of machinery, vehicles and equipment	**1**	**2**	**2**	**2**	1.75	**2**	**5**	8.75

Table 35: DWS Risk Impact Matrix for the proposed project (continued)

Aspect	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Sig.	Without Mitigation	With Mitigation
Construction Phase								
Blasting (dislodging of rock)	2	3	1	3	9	69.75	**Moderate***	**Low**
Fractures in bedrock	3	2	1	3	9	69.75	**Moderate***	**Low**
Disruption (draining of aquifers)	3	2	1	3	9	72	**Moderate***	**Low**
Operation of machinery, vehicles and equipment	3	2	1	1	7	40.25	**Low**	**Low**
Operational Phase								
Blasting (dislodging of rock)	2	3	1	3	9	78.75	**Moderate***	**Low**
Fractures in bedrock	3	2	**1**	3	9	78.75	**Moderate***	**Low**
Disruption (draining of aquifers)	3	2	1	3	9	78.75	**Moderate***	**Low**
Operation of machinery, vehicles and equipment	3	2	1	1	7	40.25	**Low**	**Low**
Closure Phase								
Pollution of water resources	3	2	1	1	7	71.75	**Moderate***	**Low**
Management of water quality	3	2	1	3	9	78.75	**Moderate***	**Low**
Operation of machinery, vehicles and equipment	3	2	1	1	7	61.25	**Moderate***	**Low**

(*) denotes - In accordance with General Notice 509 "Risk is determined after considering all listed control / mitigation measures. Borderline Low / Moderate risk scores can be manually adapted downwards up to a maximum of 25 points (from a score of 80) subject to listing of additional mitigation measures detailed below.

The pre-mitigation risks to wetland areas were determined to be moderate for all phases of the proposed underground mining. Taking into consideration the proposed mining methods, unmitigated risks could have a “regional” (or score 3) effect on the water resources for all but one aspect. This scale of risk does contribute to the moderate level of risk posed pre-mitigation. In addition to this, the duration of the risks would typically be for the life of the project (approximately 7 years) or permanent, which would also contribute to the relatively high level (moderate) of pre-mitigation risk. There is almost no mitigation which can be implemented to address the duration of the considered risks. Despite this, it is expected that the planned mining depths, bord & pillar methods and avoidance of water discharge for example do contribute to mitigating risks levels. The proposed underground mining methods will not directly pose risks to the relevant water uses (Section 21 (c) and (i)) and in light of this no legal issues are expected (score 1).

In the event the recommendations prescribed herein are fulfilled, the level of post mitigation risk can be further re-evaluated should the information be provided with a high level of confidence.

7.2 Recommendations

The following recommendations are made for the project:

- A rock engineering study must be undertaken to determine subsidence risk levels for the project area. This study must inform the size of underground pillars;
- A geotechnical study and report must be conducted to identify risks to geohydrology of the proposed area;
- A biomonitoring and wetland monitoring plan must be designed and implemented on a bi-annual basis for the life of the project;
- Should groundwater decant occur, the quality of the water should be determined and the effect upon the surface water determined. If the water quality is outside of the parameters stipulated in the Resource Quality Objectives (RQO's) a water management and treatment process should be implemented; and
- Annual subsidence monitoring should take place throughout the project area. Should subsidence develop, a scenario specific remedy to avoid further and more extensive subsidence must be put in place within 6 months of the findings. It is further noted that suitable site-specific subsidence monitoring must be conducted, this could be through the use of satellite imagery or physical surveying techniques.

7.3 Construction Phase Mitigation Measures

The following are the mitigation measures for the construction phase of the project:

- All contractors and employees must 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”;

- All ablutions, offices, storage and laydown areas must be located within the existing mining area. In addition to this, all stockpiles must also be located within the designated existing mining area, with no new areas permitted;
- Have action plans on site, and training for contactors and employees in the event of spills, leaks and other impacts to the watercourses;
- No dumping of construction material on-site may take place; and
- All waste generated on-site during construction must be adequately managed. Separation and recycling of different waste materials should be supported.

7.4 Operational Phase Mitigation Measures

The following are the mitigation measures for the operation phase of the project:

- Bord and pillar must be the implemented mining method;
- Areas where high risk for subsidence to occur must be avoided or mitigated through effective engineering controls;
- Moderate and Low Risk areas must include appropriate recommendations from the rock engineering study regarding pillar size. This must be implemented to reduce the overall risk for subsidence, particularly in regions where wetlands and watercourses are undermined;
- The implementation of an effective integrated water management plan should be adopted and to further ensure clean and dirty water are separated;
- If there will be discharge of water, then this water must to be pumped into a return water dam located within the existing mining area; and
- The edges of the road must be kept vegetated to limit the risk of erosion.

7.5 Closure Phase Mitigation Measures

- Appropriate measures need to be implemented to limit the occurrence of acid mine drainage; and
- Monitoring should be regularly conducted following decommissioning to highlight and address any issues or further impacts not realised before closure.

7.6 Unplanned Events

The planned activities will have anticipated impacts as discussed above; however, unplanned events may occur on any project and may have potential impacts which will need management. Table 15 is a summary of the findings of an unplanned event assessment from a wetland ecology perspective. Note, not all potential unplanned events may be captured herein, and this must therefore be managed throughout all phases according to recorded pollution events.

Table 36: Summary of potential unplanned events that require attention for the proposed project

Unplanned Event	Potential Impact	Mitigation
Hydrocarbon spill into riverine habitat	Contamination of sediments and water resources associated with the spillage.	A spill response kit must be available at all times. The incident must be reported on and if necessary an aquatic specialist must investigate the extent of the impact and provide rehabilitation recommendations.
Uncontrolled erosion	Sedimentation of wetland systems.	Erosion control measures and monitoring programme must be put in place.
Subsidence	Surface and interflow hydrological modifications.	Subsidence risk assessment, avoidance of high risk areas, post closure subsidence monitoring. Should subsidence occur a suitable management plan must be investigated, this may include the construction of water diversion around subsidence areas to avoid surface water loss. The required mitigation would however be site specific.
Acid Mine Drainage	Severe water quality degradation	Water treatment, post closure water monitoring and water level management.

8 Vent Shaft Risk Assessment

The risk assessment is for the proposed sinking of two (2) ventilation shafts for the project. A WULA 500m assessment area has been assumed to be applicable, with ventilation shafts also located in either the Low Risk (50m) or No Risk (175m) buffer areas. This risk assessment has considered in particular the hydropedological risks stemming from the sinking of the shafts in relation to the wetlands. Wetland seeps are the dominant wetland types proposed to be undermined. According to Ollis *et al.* (2013) seepage systems contribute significantly to recharge and stream flow regulation of the valley-bottom and floodplain systems. These seeps are located predominantly on slopes in situations where the underlying geology and topography facilitates either the discharge of groundwater to the land surface or rain- water to seep down-slope as subsurface interflow, and these linkages are the consideration for the risk assessment. The proposed project will not result in the direct loss of wetlands but the hydropedological drivers to wetlands downstream could be affected. The following list provides a framework for the anticipated impacts associated with the project:

- Infiltration of water into the fractured rock will still be dominant on midslope positions.
- This infiltrated water can still flow through fractures in the bedrock and return to the stream via bedrock flowpaths.
- It is expected that the ‘average/long-term’ supply of water to the stream via bedrock flowpaths will not be altered drastically.

Based on the conceptual hydropedological understanding it is clear that this is a very responsive landscape; with overland flow dominating. Taking into account the vent shaft locations and soil characteristics, the longer-term water regimes of soils for the vent shaft locations is expected to be moderately affected.

8.1 Sinking of Shafts

Shaft raise-boring is a shaft sinking technique which consists of an electrically powered, mechanical machine that is pinned onto the shaft collar. The process involves to first drill a pilot hole from surface to the underground workings and then attaching a reamer head onto the drill string underground. The raise-boring machine then "drills" the shaft from the bottom upwards. Reamer cuttings fall to the underground workings where it is loaded and stowed into mined out areas. The reaming process stops when the reamer head breaks though the shaft collar.

The shaft collar protrudes above ground level to prevent ingress of run-off rainwater. The shaft is made safe with a permanent barrier after completion.

The pilot hole typically has diameter of 400mm. During piloting, water is used to flush the cuttings of the pilot bit to surface. This water is contained on site, normally in surface containers, and allowed to settle before being reused for piloting and topped up as needed. After piloting this water is released into the mine's dirty water system.

Aspects associated with the respective phases of the project are presented in the subsequent sections. Findings from the DWS aspect and impact register/risk assessment are provided in Table 37, Table 38 and Table 39.

Table 37: Impacts Assessed for the proposed project

Activity	Aspect	Impact
Andrew Husted (Pr Sci Nat 400213/11)		
Construction phase	Clearing of vegetation	Impeding the flow of water. Altered hydrpedology Loss of recharge Loss of interflow
	Stripping and stockpiling of topsoil	
	Establish working area	
	Digging of settling pond	
	Construct shaft collar	
	Drilling of pilot hole	
	Reaming	
	Installation of goose neck	
	Creation of berm for storm water	
	Erection of fence (security / access control)	
	Water use for drilling	
	Removal of pilot cuttings	
	Vehicle access	
	Leaks and spillages from machinery, equipment & vehicles	
	Solid waste disposal	
	Human sanitation& ablutions	
	Re-fuelling of machinery and vehicles	
Operation phase	Shaft collar	Impeding the flow of water.
	Fence	

Activity	Aspect	Impact
Andrew Husted (Pr Sci Nat 400213/11)		
	Berm for storm water management	Siltation of watercourse. Water quality impairment.
Decommission phase	Removal of structures	Impeding the flow of water. Siltation of watercourse. Water quality impairment.
	Backfill of shaft	
	Capping with concrete slab	

Table 38: DWS Risk Impact Matrix for the proposed project

Aspect	Flow Regime	Water Quality	Habitat	Biota	Severity	Spatial scale	Duration	Consequence
Construction Phase								
Clearing of vegetation	1	1	1	2	1.25	1	1	3.25
Stripping and stockpiling of topsoil	1	1	1	1	1	1	1	3
Establish working area	1	1	1	1	1	1	1	3
Digging of settling pond	1	1	1	1	1	1	1	3
Construct shaft collar	1	1	1	1	1	1	1	3
Drilling of pilot hole	1	1	1	2	1.25	1	1	3.25
Reaming	1	1	1	1	1	1	2	4
Installation of goose neck	1	1	1	1	1	1	1	3
Creation of berm for storm water	1	1	1	1	1	1	1	3
Erection of fence (security / access control)	1	1	1	2	1.25	1	1	3.25
Water use for drilling	1	1	1	1	1	1	1	3
Removal of pilot cuttings	1	1	1	1	1	1	1	3
Vehicle access	1	1	1	2	1.25	1	2	4.25
Leaks and spillages from machinery, equipment & vehicles	1	1	1	1	1	1	2	4
Solid waste disposal	1	1	1	2	1.25	1	2	4.25
Human sanitation& ablutions	1	1	1	1	1	1	2	4
Re-fuelling of machinery and vehicles	1	1	1	1	1	1	2	4
Operational Phase								
Shaft collar	**1**	**1**	**1**	**1**	**1**	**1**	**4**	**6**
Fence	1	1	1	2	1.25	1	4	6.25

Berm for storm water management	1	1	1	1	1	1	4	6
Decommissioning Phase								
Removal of structures	**1**	**1**	**1**	**2**	**1.25**	**1**	**2**	**4.25**
Backfill of shaft	1	1	1	1	1	1	2	4
Capping with concrete slab	1	1	1	1	1	1	2	4

Table 39: DWS Risk Impact Matrix for the proposed project (continued)

Aspect	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Sig.	Without Mitigation
Construction Phase							
Clearing of vegetation	1	4	1	2	8	26	Low
Stripping and stockpiling of topsoil	1	3	1	2	7	21	Low
Establish working area	1	2	1	2	6	18	Low
Digging of settling pond	1	1	1	1	4	12	Low
Construct shaft collar	1	3	1	2	7	21	Low
Reaming	2	3	1	1	7	22.75	Low
Installation of goose neck	3	2	1	1	7	28	Low
Creation of berm for storm water	1	1	1	1	4	12	Low
Erection of fence (security / access control)	1	2	1	2	6	18	Low
Water use for drilling	1	1	1	2	5	16.25	Low
Removal of pilot cuttings	2	2	1	2	7	21	Low
Vehicle access	1	2	1	2	6	18	Low
Leaks and spillages from machinery, equipment & vehicles	3	3	1	2	9	38.25	Low

Solid waste disposal	3	3	1	3	10	40	Low
Human sanitation& ablutions	2	2	1	2	7	29.75	Low
Re-fuelling of machinery and vehicles	2	2	1	3	8	32	Low
Clearing of vegetation	2	2	1	2	7	28	Low
Operational Phase							
Clearing of vegetation	1	1	1	2	5	30	Low
Stripping and stockpiling of topsoil	1	1	1	1	4	25	Low
Establish working area	1	1	1	2	5	30	Low
Decommissioning Phase							
Clearing of vegetation	2	3	1	2	8	34	Low
Stripping and stockpiling of topsoil	1	1	1	2	5	20	Low
Establish working area	1	2	1	2	6	24	Low

All aspects considered for the three respective project phases of the proposed project were determined to pose a Low Risk pre-mitigation. These Low Risk ratings are attributed to the relatively small scale (footprint area) of the project and the type of project (vent shafts), but more importantly the Low Risk is predominantly attributed to the adherence to the prescribed buffer areas. Despite these Low Risks, mitigation measures have been prescribed to further reduce to the level of risk posed by the proposed project.

8.2 Recommendations

The following recommendations are provided:

- The placement of vent shafts is only permissible within the Low Risk and No Risk buffer areas;
- The water used for piloting must be released into the mine's dirty water handling system;
- The pilot cuttings must be removed to the existing mining area such as a rock dump, solid waste facility or stowed underground;
- All cuttings and material from reaming must stay underground and stowed in underground storage areas (mined out areas); and
- An alien vegetation management plan must be implemented for the two vent shaft areas. The management of alien vegetation must be continued for three post the decommissioning phase.

8.3 Mitigation Measures

The following mitigation measures are provided:

- Vent shaft footprint areas must be demarcated (cordoned off) to confine activities to these areas. These footprint areas must be kept to a minimum;
- The storm water berm must be created soon after stripping of the top soil, prior to other activities are undertaken;
- As much material as possible must be pre-fabricated to reduce the need for mixing within the project areas;
- During the drilling programme vehicles and machinery must make use of existing access routes as much as possible, before adjacent areas are considered for access;
- Laydown yards, camps and storage areas must be within the demarcated footprint areas;
- Drillers used for the project must have spill kits available to ensure that any fuel or oil spills are clean-up and discarded correctly;
- Have action plans /procedures on site, and training for drillers in the event of spills, leaks and other impacts;

- 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 within the demarcated footprint area. Use of these facilities must be enforced (these facilities must be kept clean so that they are a desired alternative to the surrounding vegetation);
- All waste and materials must be removed from the project areas;
- Any exposed earth should be rehabilitated promptly by planting suitable vegetation (vigorous indigenous grasses) to protect the exposed soil;
- No dumping of construction material on-site may take place; and
- All waste generated on-site during drilling must be adequately managed. Separation and recycling of different waste materials should be supported.

9 Rehabilitation Plan

Wetlands can be thought of as ecological infrastructure connecting terrestrial and aquatic environments which provide important assets to both people and biodiversity (WRC, 2016). The importance of conserving and rehabilitating wetlands has gained increased acceptance in recent years as the appreciation for their critical ecosystem services they provide such as the provision of clean water, harvestable resources, nutrient and toxicant removal, flood attenuation and stream flow regulation become more appreciated. Wetland rehabilitation is essentially the process of recovering and maintaining the integrity of a wetland that has been degraded (Macfarlane, 2008). Nowhere are these services more valuable than in water stressed countries such as South Africa. In response, South Africa has developed a robust legal framework to protect wetlands and safeguard their continued functionality through the Working for Wetlands programme and through the production of several practical Water Research Commision (WRC) guideline documents such as *Wetland Rehabilitation in Mining Landscapes: An Introductory Guide*, *Wet-RehabPlan, Wet-RehabMethods* and *Wet-RehapEvaluate*.

Mining poses a unique set of challenges for wetland management due to scale of most operations and the potential long-term hydrological and water quality implications of bringing the product to surface. The WRC (2016) document lists several impacts that tend to form the core of most rehabilitation efforts in mining landscapes. These include:

- *"Water quality, which affects the longevity or efficacy of wetland rehabilitation structures (e.g. reduction in pH will corrode gabion wire or even concrete);*
- *The deposition of heavy metals, or coal fines amongst other deposits in downstream areas, which impact on the health of wetlands, rate of rehabilitation and may even pose a risk of ignition of coal fines deposited in wetlands (with further environmental and human health implications); and*
- *Hydrology (in the form of altered flow of water though the landscape),as a result of the creation of free drainage landscapes to reduce water ingress (water make) into certain mining areas, as a result of dewatering activities that lower regional water tables, or through altered topography in areas of open cast mining".*

9.1 Strategy and Planning

9.1.1 Aims and Objectives

The overall aim of this rehabilitation plan is to remediate the impacts to wetlands associated with the existing, above-ground, coal mining operations to the target state (see Section 9.1.2) and prevent further loss of ecological integrity in future through adaptive management and monitoring. It is important to note that rehabilitation is not a static endpoint but rather an ongoing adaptive process that strives to recreate and preferably improve on the former natural state of the wetland. Although each project may have different starting and endpoints the overall result should be a net improvement on the state of the system achieved through a sound understanding of the ecological driving forces and the defined end goal. In south Africa this broad aim can be further subdivided into three themes based on projects specific situations and desired / feasible outcomes namely (1) water resources and indirect services, (2) ecosystem conservation and (3) species of conservation concern. For this project the main focus should be on improving the provision of indirect regulating and supporting services (Theme 1) with a secondary goal of improving and protecting the rehabilitated wetlands (and other wetlands in the prospecting areas to the south) to the point where they contribute meaningfully towards local and provincial targets (Theme 2) and provide suitable habitat to sustain resident populations of conservation important species (Theme 3).

To achieve the aim, three objectives will need to be met, namely to (1) appropriately plan rehabilitation efforts, (2) effectively implement the plan to restore wetland integrity and (3) maintain that integrity over the long-term. The objectives are listed in Table 40 along with their associated activities and the order in which they should take place.

Table 40: Activities required to meet the three main objectives for the rehabilitation project and the order in which they should take place

Objective	Activity	Order
Plan	Legal framework	Planning
	Budget	Planning
	Personnel	Planning
	Authorisation	Planning
	Areas to be rehabilitated	Planning
	Targets	Planning
Restore	Prevention of contaminated inputs	1
	Site clean-up	2
	Landscaping and soil preparation	3
	Erosion control measures	4
	Deactivation of artificial drains	5
	Re-vegetation	6
	Removal and control of alien invasive flora	7
	General environmental considerations	8
Maintain	Vegetation	9
	Aquatic Ecology and Water Quality	10
	Wetland Health	11
	Structural integrity of interventions	12
	Reporting	13
	Handover of the Plan	14

9.1.2 Authorisations

It is essential that all necessary permission, authorisations and licenses be applied for before any in-field wetland rehabilitation actions are taken. For a more comprehensive breakdown of applicable authorisations and the consequences associated non-compliance the reader is referred to. However, the following points are considered particularly pertinent and relevant to this project.

- It is important to note that the proposed wetland rehabilitation may require a water use licence. The onus is on the applicant to conduct a risk assessment to inform the a decision made by DWS as to whether the final rehabilitation activities to be implemented constitute either a general authorisation in terms of section 39 of NWA or a full Water Use Licence application;
- The proposed wetland rehabilitation project may involve the clean-up of contaminated soils through scraping and soil washing. This has the potential to release toxicants to downstream systems if inappropriately managed. As such it is advised that the applicant take heed of the list of waste management activities in GN 921 of 29 November 2013 and investigate with the Minister responsible of Mineral Resources as to whether a waste management licence would be needed prior to commencing with the rehabilitation of the wetland;
- Unless already done, if the soils within the wetland are deemed “significantly contaminated” by the mining activities, then the mining house must notify the Department of Environmental Affairs (DEA) of the contamination in terms of section 36 of Waste Act. This the compilation of a report on the extent of the contamination, submitted to the DEA. The DEA will then declare the site as contaminated and decide upon the appropriate course of action;
- It would be prudent for the applicant to ensure that none of the proposed rehabilitation activities would require environmental authorisation in terms of NEMA; and
- Mooiplaats Colliery will also have to practice the Duty of care, remediation of environmental damage and the polluter pays principle as stipulated in the Constitution, section 28 of NEMA and section 19 of the NWA. Under this principle the colliery is obliged, by law, to act responsibly and prevent and minimise harm to the environment and rectify it if / when it does occur.

9.1.3 Budget

It is the responsibility of the applicant to ensure that an annual budget is compiled for the implementation of rehabilitation project and that these costs are adequately captured into the mine’s annual financial budget. Costs should be allocated across three main phases namely planning, rehabilitation and monitoring and maintenance (ongoing). It is important that provision is made for, but not limited to, the for the following:

- Relevant authorizations;
- Project planning and administrative costs;
- Equipment and materials;
- Appointment of contractors, personnel and specialists;
- Plans for engineered intervention structures;
- Geotechnical investigations if required;
- Ecotoxicology / contamination assessments (to identify sources of contamination and assess significance); and

- Implementation of wetland monitoring.

9.1.4 Personnel, Roles and Responsibilities

The main responsibility for ensuring that the wetland rehabilitation is effectively managed and implemented lies with Coal of Africa's Mooiplaats Colliery and the appointed environmental practitioner but also the contractors responsible for any direct or indirect disturbance of wetlands. EIMS should advise on the responsible contractor for the overseeing the management of the rehabilitation of the relevant areas within the wetland to be conducted by the responsible contractor The Ecological Control Officer (ECO), will be responsible for the wetland monitoring and to identify aspects that may require further attention. This can be done in conjunction with a wetland specialist (overseeing and advisory role).

9.1.5 Target

Ideally, rehabilitation efforts should strive towards re-instating the reference state integrity of the system, however, this is rarely realised. Consequently, following best practice principles as presented in the guideline document Wet-RehabEvaluate (Cowden and Kotze, 2008), the targets for this rehabilitation project are based on the predicted (post rehabilitation) ecosystem health of the wetland, following successful implementation of the rehabilitation measures. This predicted health score is expressed as hectare equivalents, or the area of functional wetland, and represents the quantifiable target against which the outcomes of the rehabilitation efforts can be evaluated during the monitoring phase. Currently the unchanneled valley-bottom system to be rehabilitated (HGM Unit 6) is situated within the northern existing mine area (Figure 13) and occupies an extent of 25.2 ha and has an overall PES score of Seriously Modified (Lower E) which equates to 10.1 ha of functional wetland (hectare equivalents). The target for the rehabilitation project is to restore the integrity of the system to an overall rating of Moderately Modified (Upper C) and hectare equivalent of 15.4 representing a net gain of 5.3 ha of functional wetland habitat (Table 41).

Table 41: Current and anticipated PES ratings for HGM unit 6 following successful implementation of rehabilitation measures

HGM Unit	Hydrology	Geomorphology	Vegetation	Overall	Extent	Hectare Equivalents
Current						
6	E (6.5)	D (5.5)	D (5.8)	E (6)	25.2	10.1
Target						
6	C (3.5)	C (3.5)	D (5)	C (3.9)	25.2	15.4

In addition, the current and anticipated wetland ecosystem services, provided the rehabilitation measures are successfully implemented, is provided in Table 42. Overall rehabilitation is anticipated to increase the system's capacity for flood attenuation, phosphate assimilation, nitrate assimilation, toxicant assimilation and carbon storage by one class (from Intermediate to Moderately High). Biodiversity maintenance scores are also likely to increase as the system becomes cleaner and consequently its value from a birding and recreational perspective would increase.

Table 42: Current and anticipated ecosystem services ratings for HGM unit 6 following successful implementation of rehabilitation measures

Wetland Unit			Service	Score	
				Current	Post Rehab
Ecosystem Services Supplied by Wetlands	Indirect Benefits	Regulating and supporting benefits	Flood attenuation	2.0	2.1
			Streamflow regulation	2.7	2.7
			Sediment trapping	2.3	2.9
			Phosphate assimilation	1.8	2.3
			Nitrate assimilation	2.1	2.4
			Toxicant assimilation	2.4	2.7
			Erosion control	2.3	3.1
			Carbon storage	2.0	2.3
	Direct Benefits		Biodiversity maintenance	3.5	3.8
		Provisioning benefits	Provisioning of water for human use	1.9	1.9
			Provisioning of harvestable resources	2.0	2.0
			Provisioning of cultivated foods	1.0	1.0
		Cultural benefits	Cultural heritage	1.0	1.0
			Tourism and recreation	1.4	2.4
			Education and research	1.3	1.5
Overall			**Overall**	29.7	34.0
Average			**Average**	2.0	2.3
Threats			**Threats**	3.0	2.0
Opportunities			**Opportunities**	4.0	4.0

9.2 Restoration Actions

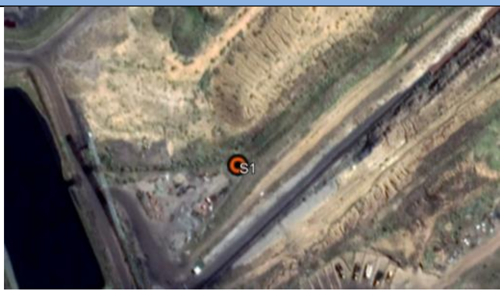
9.2.1 Prevention of Contaminated Inputs

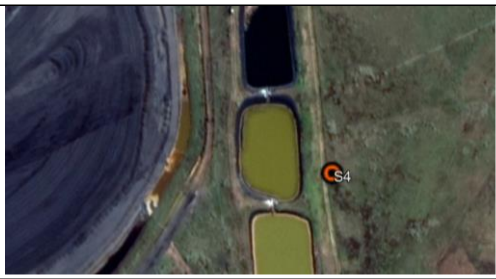
To ensure successful rehabilitation, the first and most important action will be to contain dirty water on site (i.e. closed system) and prevent leachate seeping into receiving wetlands. Preliminary investigations based on field observations and analysis of Google Earth imagery suggests that contaminated water may be entering the valley-bottom wetland and associated seeps through five potential sources. The locations of the potential sources are mapped in Figure 32 while Table 43 provides a summary of the nature of the impact and the proposed actions to remediate them. These include point source inputs from trenches (indicated by points S1 and S2) that channel runoff from the general operational area as well as through diffuse subsurface seepage, and occasionally overland flows, from the pollution control dams (PCDs) and coal stockpile (indicted by points S3-5). It is recommended that point source inputs (S1 and S2) be dealt with by effectively re-diverting flows into the existing stormwater system and ultimately the PCDs. This will require engineered hard interventions such as appropriately engineered and lined v-drains.

Subsurface seepage and occasional overland flows from the coal stockpile and PCDs present a more complex challenge and will require inputs from appropriately qualified engineers and geo-hydrologists. Thereafter, hard engineered interventions such as trenches should be constructed around these structures that are designed to effectively intercept subsurface flows and contain dirty water on site. Dirty water collected in these trenches should be pumped to the PCDs. The colliery should also consider re-evaluating its water balance estimates and if found to be under duress, take the necessary steps to ensure sufficient PCD capacity, or decrease the overall water balance through other means to prevent overflows into the environment following high rainfall events.

In the interim it is recommended that the colliery consider the feasibility of creating a contingency dam at the main outlet point south of the small PCDs (26°38'33.38"S; 30° 6'3.74"E) where a man-made depression of the sort already exists. Here, the proliferation of dense reedbeds would be encouraged to aid in phytoremediation. This dam should be constructed such that it can be easily accessed with a bulldozer to scrape contaminated sediments on a 5-year basis or following significant spill events. Scraping should occur during low flow periods (late winter) to avoid contaminating downstream wetlands. The dam should be designed with a broad spillway fitted with flow attenuation structures (e.g. small concrete blocks). The spill way should discharge into a rock bed (± 1 m wide) before entering the wetland. The slopes of the wetland the discharge point should be gently profiled to grade seamlessly into the relatively shallow cross-sectional profile of the rest of the downstream system. Figure 34 provides a conceptual layout of this intervention. Any hard interventions of this nature would, however, require water use authorisations as well as engineering and potentially geo-technical input.

Table 43: Potential sources of contamination, associated impacts and proposed actions to remediate them

Point	Notes	GPS coordinates
S1	**Description:** Runoff from the current above ground mining operations that is channelled into a 520 m long trench that runs from the PCD nearest the mine buildings to a discharge point into the eastern valley bottom near the three north-eastern PCDS. **Proposed action:** Requires engineered, hard interventions. Flows in trench should be re-diverted into dirty water stormwater system.	
S2	**Description:** Trench that runs along the southern end of the boxcut. Runoff from cleared areas is channelled along this trench which discharges into the wetland. **Proposed action:** Requires engineered, hard interventions. Flows in trench should be re-diverted into dirty water stormwater system.	

S3	**Description:** Subsurface seepage and periodic overland flows from the main coal stockpile. Overland flows during peak rainfall events have caused notable head cut erosion at the point where it merges with the S1 trench () on the south-western corner of the southern-most PCD. **Proposed Action:** Check coal stockpile liner for leakage. Requires engineered, hard intervention. Trench around the coal stockpile needs to be deep enough to effectively intercept subsurface flows. Collected water needs to be pumped to PCDs to prevent overflows.	
S4	**Description:** Subsurface seepage downstream of eastern-most PCDS. **Proposed Action:** Check liners of PCDs and coal stockpile for leakage. Effectively trap contaminated water from these structures in appropriately engineered trench designed to return dirty water to PCDs.	
S5	**Description:** Subsurface seepage downstream of northern-most PCDS. **Proposed Action:** Check liners of PCDs and coal stockpile for leakage. Effectively trap contaminated water from these structures in appropriately engineered trench designed to return dirty water to PCDs.	

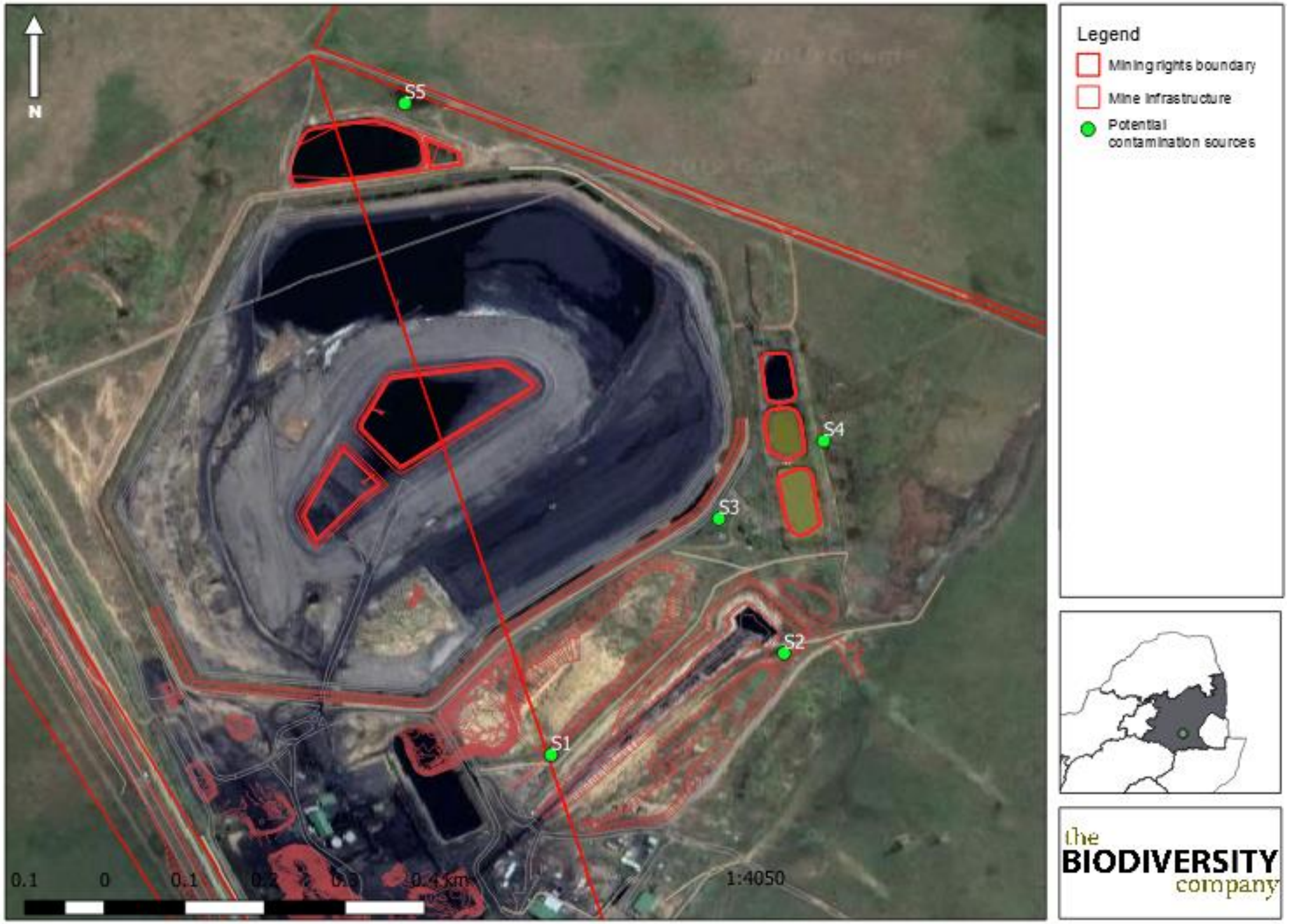


Figure 32: Locations of potential contamination sources

9.2.2 Site clean-up

Once the source of contamination has been effectively dealt with, a clean-up operation must take place. Clean-up efforts should focus on the removal of the sediments and salts and the cleansing of potentially contaminated soils in the eastern valley-bottom wetland. Precipitates should be removed by means of scraping with a bulldozer. Clean-up efforts should employ a phased approach in which only sections of the wetland are cleared to avoid denuding the whole wetland t once. These areas are indicated by the re-vegetation zones as depicted in Figure 34. Soil scraping should be restricted to re-vegetation zones 1a&b and 2a&b (the flow path of the wetland). Re-vegetation zones 1a&b should be scraped first followed by zones 2a&b. Scraping must only take place in winter to minimise contamination risk to downstream reaches and overall wetland damage.

Removed precipitate and potentially contaminated soils should be loaded onto a truck as soon as possible (i.e. within a week of scraping) and taken to an appropriately licenced, hazardous waste facility (e.g. Holfontein). Additionally, all foreign objects and waste (e.g. concrete, bricks, rubble, litter discarded conveyor belts) must be removed from the wetlands on site and disposed of appropriately. All redundant and / or broken fences (Figure 33) should be removed as these pose hazardous restrictive barriers to local wildlife.

9.2.3 Landscaping and Soil Preparation

Following site clean-up, the eastern wetland should be landscaped. Landscaping is required to not only increase the aesthetic appeal of the wetland following scraping (clean-up) but to restore the drainage properties of the wetland and promote effective plant succession and in so doing improve the distribution and retention time of water within the system. The wetland has been divided into two landscaping zones of differing priorities to avoid denuding vegetation within the entire system all at once. Landscaping should follow site clearing and likewise adopt a phased approach using the re-vegetation zones (first zones 1a&b the zones 2a&b). of the rest of the system from this junction point to the northern edge of the mining rights boundary should be done in the following winter.

Landscaping will involve the use of a bulldozer / TLB to smooth uneven ground and contour the flow path (zones 1a and 2a) such that it has a shallow slope in cross-sectional profile (no channel) and ensure that it grades smoothly into the surrounding topography through gradual banks (zones 1b and 2b). The width and direction of the flow path should mirror the current wetland shape as provided in the wetland delineation and be tapered such that it gradually increases in width into a vlei-like system before its junction the small dam beyond the northern site boundary. During landscaping care should be taken not to disrupt the soil profile. Topsoil should be appropriately stored and properly reinstated. Care should also be taken to maintain the general catena in soil texture from more sandy soils on the outer margins to more clay rich soils in the centre of the flow path. Once completed soils should be loosened and aerated to a fine seed bed in preparation for re-vegetation. Weed free compost should be added to help re-establish the organic matter lost during site clean-up and landscaping operations. Fertilizers and other chemical soil enhancers should be avoided.

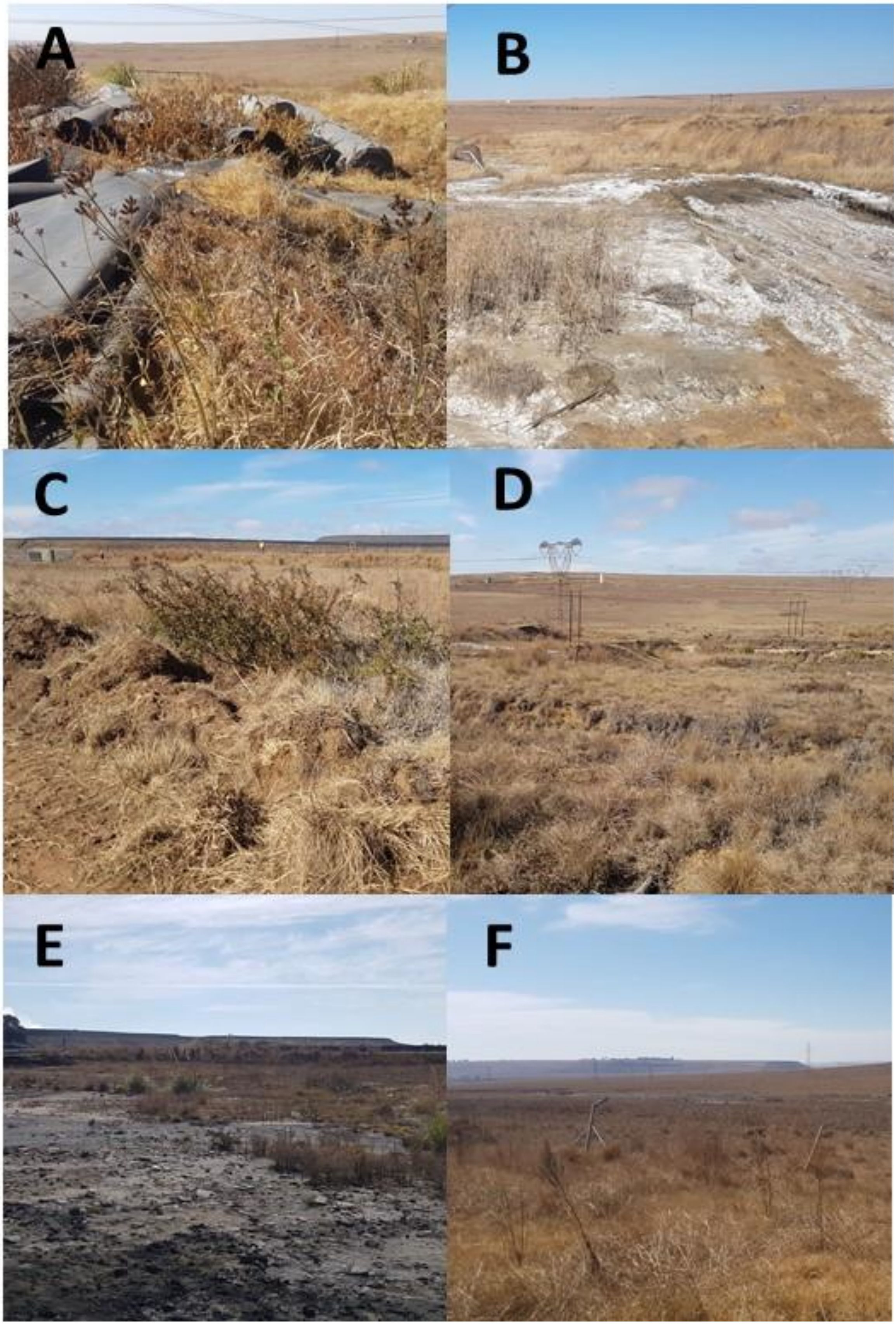


Figure 33: Aspects identified for site clean-up A) discarded conveyor material, B) salt precipitate, C) soil heaps to be levelled, D) areas requiring landscaping, E) coal wash, F) redundant broken fencing to be removed

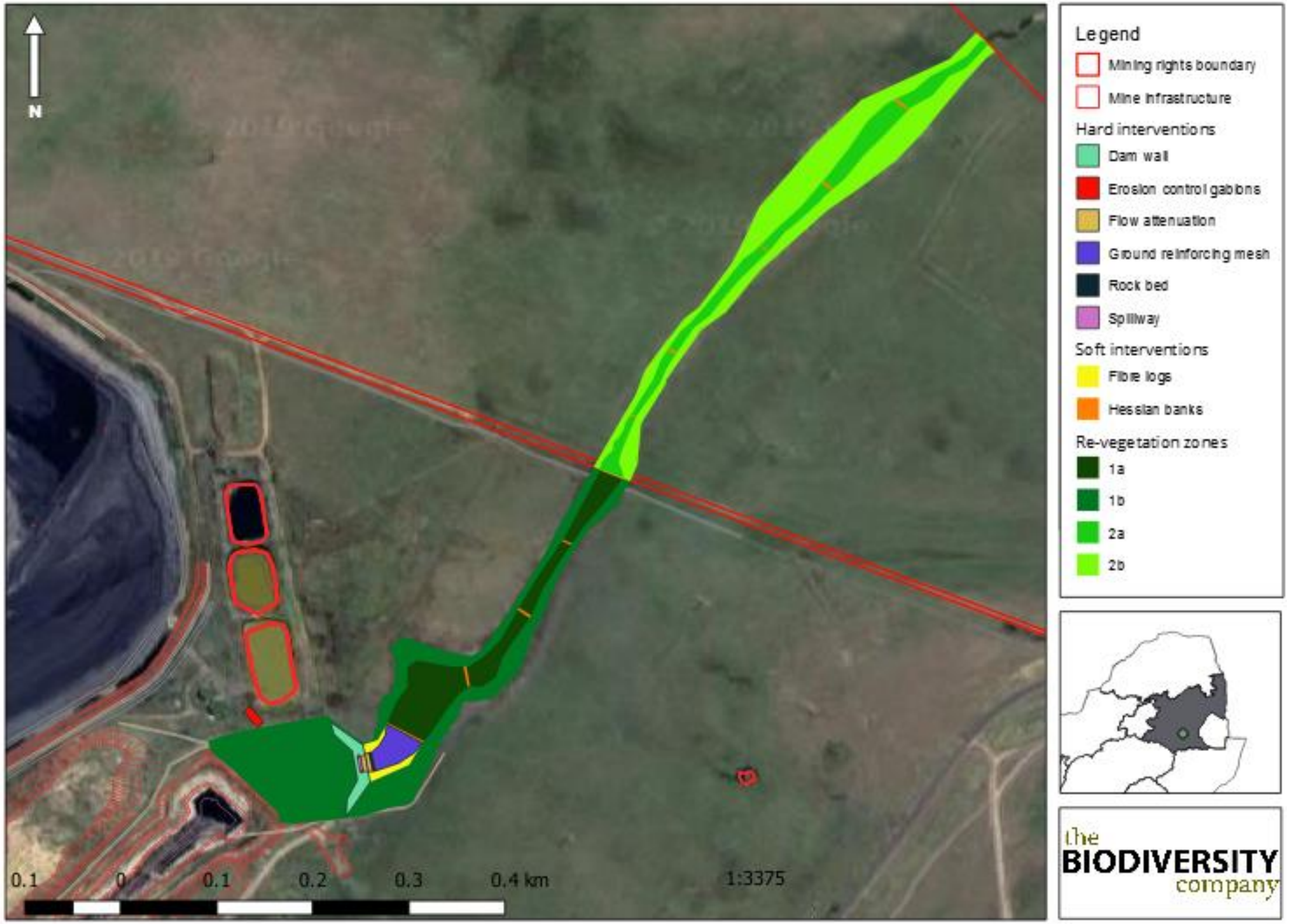


Figure 34: Locations and conceptual layouts of proposed wetland intervention measures

9.2.4 Erosion and Sedimentation Measures

Based on the ecosystem services assessment the site has a Moderately High erosive potential due to the high runoff intensity from the wetland's catchment and high erodibility of its soils. Consequently, it is important that appropriate erosion control measures are incorporated into the design of the rehabilitation project that cater for periodic bouts of high flow volumes and velocities following significant rainfall events. Erosion control should address both catchment and within system impacts. The following rehabilitation measures are prescribed for erosion and sedimentation:

- Prevention of erosion within the rehabilitated wetland will centre on appropriately address all artificial inputs (stormflows and seepage). Attempts should be made to contain dirty water within the active mine area through the re-diversion of the two trenches that are currently delivering runoff flows from the operation areas into the dirty water system and by addressing the seepage issues from the coal stockpile and pollution control dams.
- Reducing and attenuating stormflows entering the wetland by not only effectively designing (diverting runoff from the mine that is currently entering the wetland to the PCDs) and maintaining the stormwater infrastructure (e.g. repairing damaged v-drains and regularly clearing them of obstructions to prevent overflows). But by fitting all upstream culverts with flow attenuation structures constructed with rocks and concrete.
- One of the most significant erosional features that will need to be addressed before the wetland can be effectively rehabilitated is the significant head-cut erosion situated at the outlet of the potential contamination source S3. Here intervention should involve the de-activation of the drop-off (change in height) that is driving the head cut erosion by backfilling the gully and stabilising it with gabions and / or reno mattresses.
- All other erosion channels within the catchment are small and can easily be remediated through one of two methods. Shorter channels can be backfilled and compacted while longer channels may be remediated by installing soil plugs at intervals (max spacing of 1 m) along the channel to promote sediment accumulation and re-vegetation. Backfilling is deemed preferable.
- In the period between site clean-up / landscaping and re-vegetation when a portion of the wetland is denuded of vegetation and bare soils predominate, the wetland will be particularly prone to loss of sediments and erosion. To minimise the loss of sediments and reduce erosion risk during this time it is advised a series of biodegradable fibre logs (hessian tubes filled with locally cut grass and soil) be placed perpendicularly across the wetland at 50-100 m intervals and pegged in place with wooden stakes (do not use wood from *Poplar* spp.) to prevent them being washed away. These logs should span the width of the wetland (±20 m in length) and needn't be tall (<30 cm diameter).

11 February 2013 | 19 May 2016

13 May 2017 | 04 June 2019

Figure 35: Progression of headcut erosion gully situated immediately south of the eastern PCDs (26°38'32.59"S; 30° 6'2.22"E)

9.2.5 Deactivation of Artificial Drains

All trenches within the rehabilitation area must be deactivate through backfilling. These areas must be compacted, and the topsoil lightly tilled to facilitate revegetation.

9.2.6 Re-vegetation

Re-vegetation of areas denuded by disturbances, site clean-up (soil scraping and washing) and landscaping activities should be re-vegetated. Re-vegetation should follow landscaping activities in a phased approach over two consecutive growing seasons (first zone 1 then zone 2). This approach ensures that the entire system is not denuded of vegetation all at once any that any challenges / short comings identified in the first phase to be rectified in the second phase. The four zones for re-vegetation and their priority / schedule for re-vegetation are shown in Figure 34. These re-vegetation zones essentially represent the flow path (permanent seasonal saturation – zones 1a and 2a) and banks (seasonal temporary saturation – zones 1b and 2b).

The unchanneled valley bottom wetland to the east of the mining activities provides a relatively good example of the vegetation structure and species composition that should be aimed for in the rehabilitated wetland. Rehabilitation should seek to re-establish a wetland vegetation comprised of short, dense hydromorphic grasses in the temporary to seasonal zone with slightly taller sedges becoming more prevalent in the permanent zones along the flow path. Avoid creating a monoculture, species diversity is the key to wetland health and the provision of important ecosystem services such as erosion control and water quality enhancement. To achieve this outcome the following approach is advocated:

- Attempts should be made to maximise the diversity of low hydromorphic grasses and sedges throughout. The active planting of Typha capensis and Phragmites australis should be limited to areas nearest the mine (i.e. the stretch of wetland from the active mining area to the edge of Portion 1, 290) where it is needed for phytoremediation purposes, and prohibited elsewhere;

- Re-vegetation should involve the use of both re-seeding and mechanical transplanting. Re-seeding should occur in both the flow path and banks to establish a vegetation base while mechanical transplanting of wetland plant sods should take place mainly within the flow path;

- As the saturation, nutrient and oxygen levels will vary markedly depending on the hydrological zonation (permanent, seasonal and temporary) care should be taken to sow or plant the appropriate plant species in each re-vegetation zone (flow path or bank) as indicated in (Figure 34). The species are generally common and adaptable species that show a tolerance to disturbed soil conditions;

- Only locally indigenous species that are adapted to local climatic conditions should be used. Perennial species should be prioritised for transplanting. Good quality planting material or seed must be readily available;

- Revegetation should commence immediately after landscaping and the preparation of the seedbed, preferably in early spring when conditions for germination and rootstock establishment are optimal. Planting should preferably be timed to take place 1-3 days following a significant rainfall event when soils are within 10% of the field capacity (maximum saturation level);

- Topsoil should be stored for later use and where necessary supplemented with imported topsoil. With correct storage and replacement of topsoil species diversity should improve rapidly as species present in the seedbank also germinate;

- Transplanted vegetation can be sourced from nurseries and / or sustainably harvested from local wetlands, with due authorisation. Most of the plants should be harvested from the areas that will be scraped during the site clean-up and landscaped and supplemented with plants from surrounding wetlands. Harvesting should target sedges, rushes and grasses;

- Harvesting would involve carefully digging up parent plants and separating the material into as many individual sods as possible. Parent plants should be large specimens with a high root biomass. These plants should be temporarily stored onsite and transplanted later. Try to minimise the time spent the harvested plants spend in nurseries between harvesting and replanting back in the wetland;

- Try to limit collection and disturbance to wetlands when collecting sods by sticking to the designated collection areas and utilising a single access path. Once complete the soil along the collection paths must be loosened;
- The sods should be planted to an approximate depth. This will vary depending on the size of the plant but will be around 20cm on average. The recommended planting density depends on plant size (range from 1 plant / m2 for large plants such as rushes to 8 pants / m2 for small sedges and grasses) but is generally around 2–3 plants / m2 for average sized plants. When transplanting sods attempt to retain as much of their roots and soil as possible and maintain saturation levels similar to where they were removed from;
- For larger sedges and rushes trim the foliage (about 10 to 15cm) to reduce evaporative losses during transplanting. At least some live foliage must remain above ground after planting to drive water uptake and survival;
- Keep plants that are being prepared for later transplanting out of direct sunlight (fodder bags work well) and bag / re-plant as soon as possible. Uprooted plants left in the sun for a several hours will die. Conversely, those left in bags for several days will begin to rot; and
- Avoid the use of fertilizers or any other chemicals or soil enhancers during re-vegetation.

Table 44: Recommended species for revegetation within each zone (flow path or banks).

Species	Growth Form	Seeds / sods	Approximate Application rate
Flow path (bed)			
Imperata cylindrica	**Grass**	**Sod & seeds**	**5000 seeds/ 100m^2**
Leersia hexandra	**Grass**	**Sods**	**-**
Typha capensis	Grass (reed)	Sods	-
Phragmites australis	Grass (reed)	Sods	-
Cyperus compresus	Sedge	Sod & seeds	400 seeds/ 100m0
Cyperus congestus	Sedge	Sod & seeds	400 seeds/ 100m1
Cyperus laevigatus	Sedge	Sod & seeds	400 seeds/ 100m2
Kyllinga erecta	**Sedge**	**Sods**	**-**
Banks			
Agrostis lachnantha	**Grass**	**Sods / seed**	**4000 seeds/ 100m1**
Andropogon eucomus	**Grass**	**Seed**	**4000 seeds/ 100m2**
Aristida congesta subsp. Congesta	Grass	Seed	4000 seeds/ 100m3
Setaria sphacelata var. sericea,	Grass	Seed	4000 seeds/ 100m5
Imperata cylindrica	Grass	Sods & seeds	5000 seeds/ 100m2
Sporobolus africanus	Grass	Seed	300 seeds / 100m2
Sporobolus fimbriatus	Grass	Seed	300 seeds / 100m2
Digitaria eriantha	Grass	Seed	300 seeds / 100m3

Species	Growth Form	Seeds / sods	Approximate Application rate
Eragrostis gummiflua	**Grass**	**Seed**	**800 seeds / 100m2**
Scirpoides dioecus	**Sedge**	**Sods**	**-**

9.2.7 Removal and Control of Alien Invasive Flora

Land users are required by law, to remove and / or control Category 1 species alien invasive species (AIS) according to the National Environmental Management: Biodiversity Act (Act 10 of 2004) (Government Gazette No 78 of 2014). Additionally, unless authorised thereto, in terms of the National Water Act, 1998 (Act No. 36 of 1998), no land user shall allow Category 2 plants to occur within 30 meters of the 1:50 year flood line of a river, stream, spring, natural channel in which water flows regularly or intermittently, lake, dam or wetland. Category 3 plants are also prohibited from occurring within proximity to a watercourse.

This section builds on the *Invasive Plant Species Control and Eradication Plan* that was recently conducted for the Mooiplaats Colliery on behalf of Geo Soil and Water (TBC, 2019). From this study it is apparent that the although the rehabilitation area does not support large stands of alien trees (e.g. *Eucalyptus* spp.) and still maintains large tracks of alien-free hydropmorphic grassland, patches of alien and invasive species do, however, occur in localised areas associated with mine workings or other areas of disturbances. Category 1b species detected on site are listed in Table 45 together with their recommended methods of control. Point localities indicating particular significant stands of these species requiring priority removal are shown in Figure 37.

It is very important to note that no chemical or hormonal control of AIS must be employed within any wetland area or their associated buffers. Although Table 45 includes chemical and hormonal control options these are intended for terrestrial areas only. In the wetlands themselves only mechanical control (i.e. removal of whole plant by hand) should be permitted. Although listed as a Category 1 b species the lowest clearing priority should be afforded to *Tamarix ramosissima* due to its role in slope stabilisation and phytoremediation.

Figure 36: Category 1b listed alien and invasive species on site A) Cirsium vulgare, B) Solanum sisymbriifolium and C) Cortaderia selloana

Table 45: NEMBA listed AIS detected within the project area together with their recommended control method, adapted from TBC (2019).

Scientific Name	Common Name	NEMBA Category	Recommended clearing strategy
Cirsium vulgare	Spear thistle	1b	Control of this plant should be conducted in prior to flowering to optimise results. This plant is easily controlled with regular cultivation and is susceptible to hormone and contact herbicides (Bromilow 2010).
Cortaderia selloana	Pampas Grass	1b	The best control for this grass species is repeated applications of systemic herbicide. It is imperative that the herbicide application is repeated to ensure that the roots of this plant are killed. If removed by hand, it is important to wear protective clothing. Fire does not effectively control this grass species (Bromilow 2010).
			Mechanical control: Dig or grub out seedlings or small plants. Chainsaw small plants and remove sizeable plants by bulldozer. Compost or leave on site to rot down. Burn or bury any flowerheads.
			Weed wipe (all year round): glyphosate (200ml/L + penetrant).
			Gallant (150ml/10l + crop oil) for most sites or glyphosate (100ml/10L + penetrant) for very dense sites. Use a marker dye to avoid wastage and a foaming agent to help prevent spray drift. Leave the plants in the ground until the roots have died off (Weedbusters.org.nz).
Datura ferox/ stramonium	Large thorn apple	1b	Mechanical removal by hand pulling for small infestation or when small. Post emergence herbicides (Bromilow 2010).
Pennisetum clandestinum	Kikuyu Grass	1b	Herbicide with the chemical glyphosate should be used for control. (Bromilow 2010).
Phytolacca octandra	Inkberry	1b	Pull out small plants: Leave on site to rot down, minimise disturbance. Slash stems close to ground. Leave on site to rot down. Cut down and paint stump (all year round): metsulfuron-methyl 600g/kg (1g/L) (Weedbusters.org.nz).
Pyracantha angustifolia	Yellow firethorn	1b	Mechanical removal.
Solanum sisymbriifolium	Dense-Thorned Bitter Apple	1b	Mechanical removal.
			Bio-control *Gratiana spadicea* (Chrysomelidae) (Methods recommended by the Working for Water Programme).
Tamarix ramosissima	Pink Tamarisk	1b	Mature plants – cut stump and treat with fluroxypyr / picloram 80 / 80 g/L ME Plenum 160 ME (L7702).
Verbena bonariensis	Wild Verbena	1b	Can easily be controlled by cultivation and with broadleaved herbicides. The mature plant is tough and more tolerant to herbicides and will need to be hand pulled (Bromilow 2010).

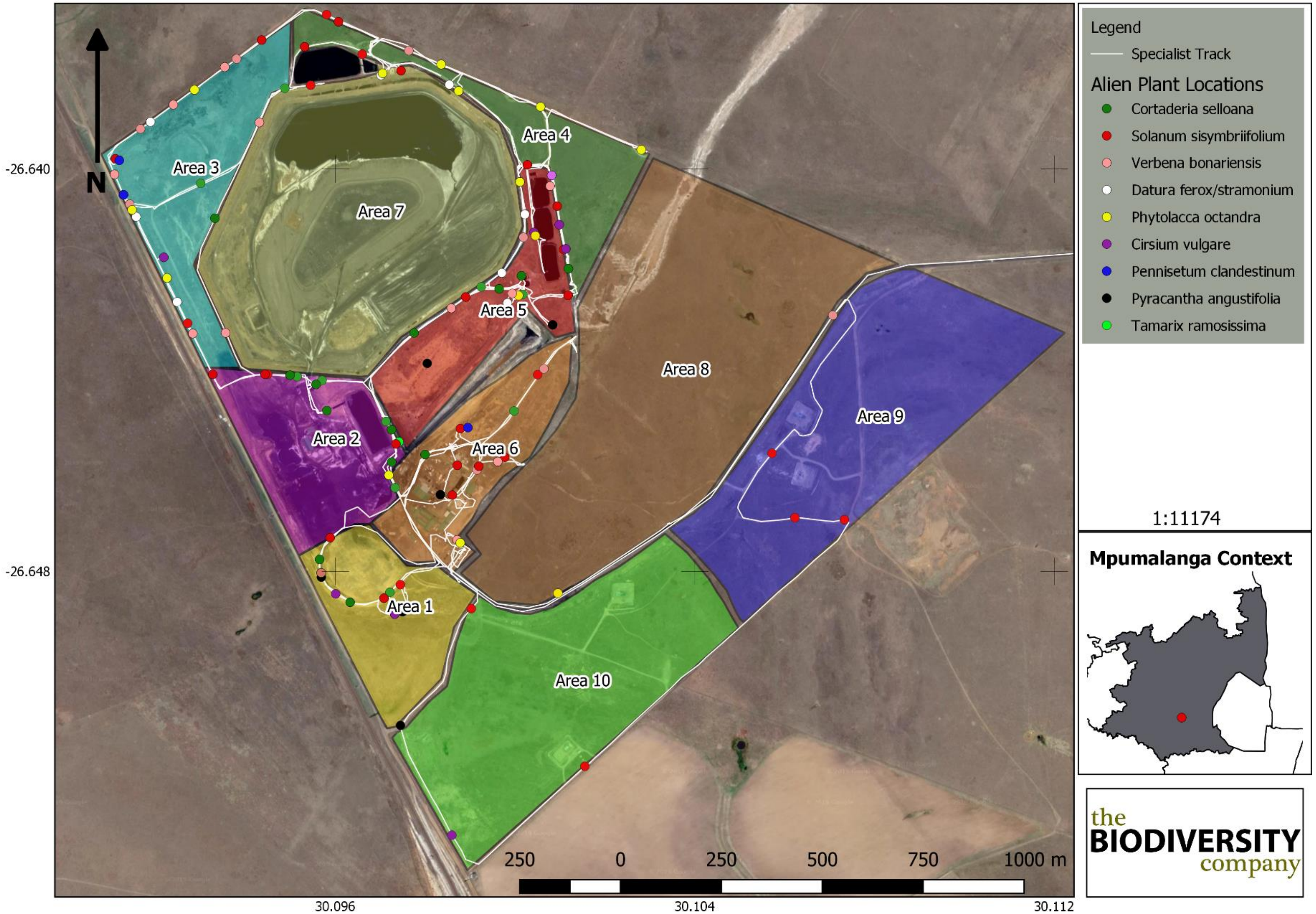


Figure 37: NEMBA Category 1b Invasive species (and locations) recorded during the site visit (TBC, 2019).

9.3 Monitoring and Maintenance

The monitoring plan has been designed to be achievable and realistic for the nature of the project. The plan will provide details as to the frequency of the monitoring efforts, the location of these efforts and what should be monitored. The primary focus for the monitoring plan is to evaluate the success of the rehabilitation efforts. Numerous monitoring frequencies have been proposed for this aspect of the project, the details of which are presented in Table 46. Further descriptions (clarity) of the referred to frequencies is discussed below.

Rehabilitation: Monitoring will be required for the wetlands during the rehabilitation period to determine if the measures are being applied correctly, and if any unforeseen issues need to be addressed. This monitoring can be undertaken by the Environmental Control Officer (ECO) appointed to oversee compliance with the Environmental Management Plan (EMP). A wetland specialist be appointed to monitor the PES and ecosystem services provided by the system on an annual basis.

Post-rehabilitation: After completion of the rehabilitation phase wetland areas should be monitored to evaluate the success of the rehabilitation efforts. In the unlikely event of potential "risks" to the systems being identified, this inspection may allow for corrective measures to be applied. This monitoring can be undertaken by the ECO appointed to oversee compliance with the EMP.

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

- Extent of erosion gullies;
- Recovery of the vegetation layer;
- Extent of alien vegetation establishment;
- Hydrology and inundation of the systems;
- The stability of the embankments;
- The attenuation of the wetland systems (including settling ponds); and
- Extent of sedimentation of the wetlands.

Annual monitoring: After completion of the season monitoring, it is recommended that the areas be monitored on an annual basis, preferably in the middle of the rainy season (January). This inspection must include aspects from all the above-mentioned monitoring efforts, but should also include a general inspection of the wetland systems.

Some best practice recommendations that must be incorporated into all monitoring efforts include the following:

- In the event of issues being noted, these may include leaks, erosion gullies, poor vegetation recovery, sedimentation etc., these should be reported, and corrective measures applied immediately.

- Corrective measures may include the full suite of rehabilitation efforts or part thereof, this will be dependent on the issues being recorded. It is recommended to consult the relevant specialist (wetland / engineer) for the best possible solution.

- In the event that issues not pre-empted in this report are identified, similarly, it is recommended to consult the relevant specialist (wetland / engineer) for the best possible solution.

- The discretion of deciding when to consult a specialist should lie with the ECO during the construction phase and the appointed independent environmental auditor during the operational phase.

- Monitoring should include fixed-point photography so that trends can been monitored and progress recorded. Photography may also help to identify potential issues or risks that would need to be addressed.

Table 46: The proposed monitoring plan for the project

Variables	Methods	Monitoring Frequency	Indicator	Corrective Action
Wetland health and ecosystem services	• Conduct PES and ecosystem services assessments on rehabilitated wetland to gauge success of rehabilitation efforts	• Annual (peak of growing season e.g. January) • Commence at the during rehabilitation and continue for at least three years, following successful completion of intervention measures.	• Hydrology, geomorphology and vegetation • Ecosystem services assessment criteria	• Adapt rehabilitation approach accordingly.
Integrity of rehabilitation structures (attenuation ponds / gabions)	• On-site inspection • Fixed point photography	• After rehabilitation • Seasonal for the first two years and rapidly after heavy rainfall • Thereafter annually	• Extent and duration of attenuation. • Establishment of vegetation	• Structures should be fixed where possible or new structures should be implemented or constructed where required
Water quality	• Sample collection and analysis as a certified laboratory	• Bi-annually for the life of the project	• Parameters must be within Target Water Quality Range for drinking water standards (DWS, 1996)	• Regular inspections and monitoring of the wetlands. • Replacement of faulty or failing equipment and / or infrastructure
Vegetation cover	• Monitor species and cover abundance • Monitor indigenous vs alien plant encroachment • Fixed point photography	• After rehabilitation • Seasonal for the first two years • Thereafter annually	• Establishment of primarily indigenous plants • Ground cover abundance is approximately 60% after the first year, and 80% after year two and 100% thereafter.	• Replanting of indigenous plants should be done at sites of concern
Erosion	• On-site inspection • Fixed point photography • Compare to adjacent areas	• After rehabilitation • Seasonal for the first two years and soon after heavy rainfall events	• Areas with no cover • Erosion gullies and headcuts • Storm water discharge area	• Short term: Rocks / boulders, and on-site debris • Medium term: Replanting of indigenous vegetation • Long term: Rehab methods that may include gabion baskets, mattresses and should be discussed with specialists.

Variables	Methods	Monitoring Frequency	Indicator	Corrective Action
Sedimentation	• On-site inspection • Fixed point photography	• During & after rehabilitation • Seasonal for the first two years and soon after heavy rainfall events • Thereafter annually	• Excess sediment in wetlands	• Sources of sedimentation should be noted and addressed • If possible, excess sediment can be removed manually.
Exotic Invasive Plant Species	• Monitor exotic invasive plant encroachment • On-site inspection • Fixed point photography	• After rehabilitation and follow- up clearing • Seasonal for the first two years • Thereafter annually	• Establishment of exotic invasive plant species	• Regularly survey the property to detect any new or emerging listed invasive plant species; • Continue to apply suggested control measures as required tackling areas of dense infestation first. Do not use chemicals for the removal process within wetlands or their associated buffers • All mechanically removed plants must be collected, piled and burnt. • Do not allow emerging or new species to produce seeds, or start growing vegetative, act immediately by removing them; • No listed invasive and alien plant species must be planted • Areas bordering onto neighbouring land must be prioritized for control to prevent existing invasive plants from spreading beyond the boundaries of the property; and • No listed invader animal species must be introduced on the property. • Update the species list by including these species and indicate where on the property they were located.

10 Conclusion

Wetland systems were grouped and assessed per drainage areas associated with the main watercourses into which they drain, namely the Vaal (located centrally), Witpuntspruit (situated in the north) and Vaal Southern Tributary (located in the south-west). The largest grouping of HGM units is associated with the Vaal River Floodplain which effectively bisects the expansion area. In total over 68 discrete wetland areas were delineated during the survey within the project area and surrounding 500 m regulated area.

Overall the Vaal River Floodplain provides by far the highest ecosystem services and was assigned a rating of High. All other HGM units provide Moderately High levels of ecosystem services except for HGM unit 7 which makes a Moderate contribution. Overall, most of the wetland systems associated with the Vaal are in a relatively good state and were assessed as Moderately Modified (C). Exceptions included HGM unit 3 which was classified as Largely Natural (B) and HGM unit 4 which was classified as and Largely Modified (D). The two northern HGM units associated with the Witpuntspruit (within the existing mine area) are impacted by the presence of the mine and were rated as Seriously (E) and Moderately Modified respectively.

On a regional scale the Vaal and its Southern Tributary Floodplains are classified as Phase 1 FEPAs while the Witpuntspruit in the north is classified as a Phase 4 FEPA. A portion of the Vaal River Floodplain within the expansion area is classified as a Wetland FEPA. Wetlands in Portion 3, 295 of the expansion area S102 676PR fall within a protected area. At a more local scale the ecological importance and sensitivity of HGM unit 1 scored Very High while most other systems, with the exception of HGM units 4 and 7 (Moderate), scored High.

Desktop information indicates that the Witpuntspruit is largely modified, and that the Vaal River reach considered in this study is moderately modified. The Ecostatus determination indicated that the Witpuntspruit was in a moderately modified state. This was attributed to serious water quality and flow modifications to the reach, furthermore, the presence of a largely intact macroinvertebrate and fish communities indicated stable, but modified conditions.

The study found that the Vaal River reach assessed was in a moderately modified state. This was attributed to habitat modifications within the reach, as aquatic biota was found to be largely natural to moderately modified. Several key macroinvertebrate taxa were absent from the system, indicating moderate to long term impacts. Spatial and temporal trends of the study indicated that a deterioration of water quality was observed between the up and downstream sites on the Witpuntspruit, indicating an influx of pollutants from the Mooiplaats Colliery as observed by elevated dissolved solids at site MPD.

The proposed mining operations will be underground with no surface access points. It has been assumed that the mining depths and board & pillar sizes will be adequate to mitigate any expected risks to wetlands. Further to this, the implementation of the proposed mitigation measures will reduce the level of risk to a Low Risk level post mitigation for all phases of the project. In the event the recommendations prescribed herein are fulfilled, the level of post mitigation risk can be further re-evaluated should the information be provided with a high level of confidence.

The risk assessment was also completed for the proposed sinking of two (2) ventilation shafts, located in either the Low Risk (50m) or No Risk (175m) buffer areas. This risk assessment considered in particular the hydropedological risks stemming from the sinking of the shafts in relation to the wetlands. Based on the conceptual hydropedological understanding of the area it is clear that this is a very responsive landscape; with overland flow dominating. Taking into account the vent shaft locations and soil characteristics, the longer-term water regimes of soils for the vent shaft locations is expected to be moderately affected, posing overall Low Risks to the wetlands.

In terms of the rehabilitation of wetlands associated with the mining area resources should be prioritised around the remediation of the eastern limb of HGM unit 6. This is an unchanneled valley-bottom system that has been impacted by stormwater runoff, soil disturbances, significant salinization and potentially other contaminants associated with mine seepage. The most important objective influencing the success of the rehabilitation project will be to contain this dirty water on site (i.e. closed system) and prevent leachate seepage into receiving wetlands. Preliminary investigations based on field observations and analysis of Google Earth imagery suggests that contaminated water may be entering the valley-bottom wetland and associated seeps and through five potential sources. It is recommended that point source inputs (S1 and S2) be dealt with by effectively re-diverting flows into the existing stormwater system and ultimately the PCDs. This will require engineered hard interventions such as appropriately engineered and lined v-drains.

In the interim it is recommended that the colliery consider the feasibility of creating a contingency dam at the main outlet point south of the small PCDs (26°38'33.38"S; 30° 6'3.74"E) where a man-made depression of the sort already exists. Here the proliferation of dense reedbeds would be encouraged to aid in phytoremediation. Once the source of contamination has been effectively dealt with, a clean-up operation must take place. Clean-up efforts should focus on the removal of the sediments and salts and the cleansing of potentially contaminated soils in the eastern valley-bottom wetland. Clean-up efforts should employ a phased approach in which only sections of the wetland are cleared to avoid denuding the whole wetland at once. Landscaping should follow site clearing and likewise adopt a phased approach using the re-vegetation zones (first zones 1a&b the zones 2a&b). of the rest of the system from this junction point to the northern edge of the mining rights boundary should be done in the following winter. One of the most significant erosional features that will need to be addressed before the wetland can be effectively rehabilitated is the significant head-cut erosion situated at the outlet of the potential contamination source S3.

Re-vegetation should follow landscaping activities in a phased approach over two consecutive growing seasons (first zone 1a&b then zone 2a&b). This approach ensures that the entire system is not denuded of vegetation all at once any that any challenges / short comings identified in the first phase to be rectified in the second phase. The unchanneled valley bottom wetland to the east of the mining activities provides a relatively good example of the vegetation structure and species composition that should be aimed for in the rehabilitated wetland. Rehabilitation should seek to re-establish a wetland vegetation comprised of short, dense hydromorphic grasses in the temporary to seasonal zone with slightly taller sedges becoming more prevalent in the permanent zones along the flow path.

Overall, it is anticipated that the wetland rehabilitation efforts, if implemented successfully, would result in an improvement of the PES of the system (HGM Unit 6) from Seriously Modified (Lower E) to Moderately Modified (Upper C) representing a net gain of 5.3 hectare equivalents or in other words a 50% increase in the extent of functional wetland.

Considering the status wetland and aquatic ecosystems and the nature of the project in respect to the watercourses, the proposed project has the potential to negatively affect local ecology. No fatal flaws were identified for the proposed underground mining activities. Environmental authorisation must take into consideration the specialist recommendations prescribed for this assessment.

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