ASSESSMENT OF WETLANDs ASSOCIATED WITH THE SYFERFONTEIN BLOCK 4 AREA, MPUMALANGA PROVINCE

SASOL MINING (PTY) LTD

APRIL 2014

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EXECUTIVE SUMMARY

INTRODUCTION

Sasol Mining (Pty) Ltd intends to extend their mining operations into the Block 4 reserves area. Mining is proposed to take place underground, with no surface infrastructure and is expected to take place in a brownfields area. This report will serve as a detailed EIA-Phase assessment of wetland areas associated with the study area. Included in this report is the Impact Assessment, as well as a discussion of mitigation and management measures. Wetland habitat in South Africa is under pressure due to expanding mining development, particularly in the Mpumalanga Province. It is approximated that 35-50% of the original natural wetlands in South Africa have been destroyed due to human influence. The preservation of these systems should be a matter of urgency. One of the major consequences of underground mining is the collapse of unconsolidated surface sediments may take place immediately or may be delayed for a number of years and can result in loss of wetland habitats, as well as their connectivity.

METHODOLOGY

A brief site visit was undertaken in November 2013 order to confirm the presence of wetlands on site and to assess their ecological state. An additional survey took place in April 2014 in order to confirm the boundaries of wetlands on site and to account for seasonal variation. The wetland delineation was conducted on desktop-level using 1:50 000 topographic maps and aerial photographs. Wetlands were classified into Hydro-geomorphic units based on geomorphological characteristics; water movement into, through and out of the wetland; and landscape / topographic setting.

The wetland integrity and functionality assessment was completed via the aid of the most relevant South African tools, namely: WET-Health; WET-EcoServices and Ecological Importance and Sensitivity (EIS).

The impact assessment was conducted using a standard rating scale, whereby the severity, spatial scale, duration and probability were assessed.

WETLAND ASSESSMENT FINDINGS

The study area falls within the quaternary catchment B11D, falling part of the Upper Olifants River Management area, allocated a Low to Marginal ecological status due to the impacts of mining and water contamination in particular. According to the National Freshwater Ecosystem Priority Areas (NFEPA), the majority of wetlands on site have been assigned a rank of 6 (indicating that they were not regarded as nationally significant) and some areas of seepage wetland were allocated a rank of 2 (indicating that they were important for the maintenance of biodiversity). None of the wetlands on site fall within any important habitat according to the Mpumalanga C-plan and all are regarded as ‘not required’.

Wetlands were delineated based on desktop information and were classified into HGM units. A total of 881.38 ha of wetland habitat was delineated. The majority of wetlands identified belong to the channelled valley bottom wetlands (511.78 ha) in addition to floodplain, unchannelled valley bottom, hillslope seep and pan units.

Wetlands that showed connectivity to major watercourses were grouped into two main categories for the integrity and functionality assessment, namely: the Vaalbankspruit and the Trichardspruit and Dwars-in-die-wegspruit. Pans were assessed separately. The Vaalbankspruit wetlands were highly impacted on by damming and roads across wetlands and were allocated a PES of ‘D’ (largely modified) and the remainder of wetlands were allocated a ‘C’ (moderately modified).

All valley bottom systems yielded similar results for the EcoServices assessment, with nutrient processing and flood attenuation scoring High values. The pans received High scores for sediment trapping, nutrient processing and erosion control.

DISCUSSION AND CONCLUSIONS

If underground mining is to commence, it is imperative that the impacts of development and operation on wetlands are thoroughly assessed in order to prevent loss of wetland habitat. The greatest identified risk at this stage is subsidence of surface ground underlying wetland areas and a geotechnical investigation is recommended in order to determine this.

Based on the low-risk nature of the proposed underground mining project, as well as the fact that less than 10% of the site is comprised of wetlands, it can be deduced that the overall impacts of the Syferfontein underground coal mine on wetland habitat is expected to be minimal.

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LIST OF ABREVIATIONS

Abbreviation	Explanation
CV	Curriculum Vitae
DM	District Municipality
DWA	Department of Water Affairs
DWAE	Department of Water and Environmental Affairs
DWAF	Department of Water Affairs and Forestry
Digby Wells	Digby Wells Environmental
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
HGM	Hydro-geomorphic
NEMBA	National Environment Management: Biodiversity Act
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act
MAP	Mean Annual Precipitation
MAT	Mean Annual Temperature
MAPE	Mean Annual Potential Evaporation
PES	Present Ecological State
WMA	Water Management Area
WULA	Water Use License Application

1. INTRODUCTION

Wetlands are sensitive ecosystems that perform many complex functions including the maintenance of water quality, carbon storage, stream-flow regulation, flood attenuation, various social benefits as well as the maintenance of biodiversity (Wet-EcoServices Manual, 2008). The Ramsar Convention on Wetlands refers to wetlands as one of the most important life support systems on earth owing to the services provided. Wetlands are defined according to the National Water Act (NWA, Act 36 of 1998) as:

"land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

Wetlands in South Africa however, are poorly conserved owing primarily to a general underestimation of the ecological and economic importance of these systems (Swanepoel and Barnard, 2007). It is approximated that between 35-50% of all the wetland areas within South Africa have been destroyed as a result of anthropogenic stressors (Swanepoel and Barnard, 2007) and a cumulative loss of these important systems is on-going. Some of the major contributing factors to the decline of wetlands in South Africa include mining, industrial and agricultural activities as well as poor treatment of waste water from industry and mining (Oberholster *et al.*, 2011).

Coal mining in Mpumalanga causes destruction of wetlands via direct impacts such as removal of habitat, alteration of flow and contamination of water, but also indirectly through the drawdown of groundwater resources during the dewatering process (van Der Walt, 2011). Dewatering has cumulative impacts on wetlands, which are complex, interlinked systems in this region. South Africa holds extensive coal reserves and coal accounts for approximately 92% of South Africa's energy generation (WWF, 2011).

Underground mining, particularly in Mpumalanga due to bord and pillar methods, has frequently resulted in unplanned surface collapse (Ochieng *et al.* 2010). This collapse has been the cause of ground and surface water contamination due to acidification and salinisation of nearby aquifers. Blodget and Kuipers (2002) elaborates that subsidence can cause fissures or pits which may result in loss of large volumes of ground or surface water if connected to the stream network. Although mining is an inevitable consequence of the compounding demand for fossil fuels, these requirements can be met by planning mining in such a way that sensitive areas are avoided. The protection of natural wetland resources should be a matter of utmost urgency and importance in the Highveld and in South Africa. It is imperative that wetlands are managed in a sustainable way and that they are not damaged during the process of meeting the needs of the growing South African economy. This report serves as an EIA-Phase wetland assessment of the Syferfontein Block 4 area, identifying and delineating wetlands on site, as well an assessment of integrity and functionality of these systems.

2. TERMS OF REFERENCE

Digby Wells Environmental (Digby Wells) was commissioned by Sasol Mining (Pty) Ltd to conduct a wetland assessment for the Syferfontein mining area into the Block 4 reserves to feed into the Environmental Impact Assessment (EIA) report. Digby Wells understands that there is no surface infrastructure proposed for this project. The current wetland assessment is designed to define wetland areas within the area of interest and to identify the ecological relevance of each assessed wetland area. A scoping-level assessment of wetlands, comprised primarily of desktop information in addition to limited ground-truthing, has already been completed for the study area, as well as the proposed alternative extension areas. The EIA-phase includes a thorough wetland delineation, complete with ground-truthing in the field and an *in situ* integrity and functionality assessment. Furthermore, the EIA report will include an Impacts Assessment as well as mitigation and management recommendations. This survey supports the following regulations, regulatory procedures and guidelines:

- Section 19 of the National Water Act (Act 36, 1998);
- Section 21 (c), (g) and (i) of the National Water Act (Act 36 of 1998);
- Section 21 of the Environment Conservation Act, 1989;
- Section 24 of the Constitution – Environment (Act 108 of 1996);
- Section 5 of the National Environmental Management Act (Act 108 of 1998) and
- Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas.

3. AIMS AND OBJECTIVES

The aim of this study was to conduct an integrated ecological wetland assessment for the Syferfontein Block 4 reserves project area. In order to achieve this aim, the following objectives were considered:

- The identification and the delineation of all wetland areas within the area under consideration for underground mining;
- A description and characterisation of the identified wetland areas;
- Determination of the wetland ecological integrity (WET-Health) of the units;
- Determination of the Ecological Importance and Sensitivity of the units;
- The description of ecological services (WET-EcoServices) provided by the wetlands;
- An impact assessment of the construction and operation of the proposed underground coal mine, and
- Provision of management and a mitigation measures for the identified impacts on wetlands on site.

4. EXPERTISE OF THE SPECIALISTS

The Digby Wells Biophysical Department is comprised of a team of qualified and experienced environmental scientists. Members specialise in their respective fields and the senior members are registered as Professional Natural Scientists. Appendix A lists the detailed Curriculum Vitae for the specialist involved in this study.

5. METHODOLOGY

5.1. Wetland Identification and delineation

Maps were generated from 1:50 000 topographic maps and aerial photographs, onto which the wetland areas were identified and preliminary wetland boundaries were delineated at the desktop level. The identified wetlands were temporarily classified according to their Hydro-geomorphic (HGM) Unit determinants based on modification of the system proposed by Brinson (1993), and modified for use by Marneweck and Batchelor (2002) and subsequently revised by Kotze *et al.* (2004). The HGM Unit system of classification focuses on the hydro-geomorphic setting of wetlands which incorporates geomorphology; water movement into, through and out of the wetland; and landscape / topographic setting. Once wetlands have been identified, they are categorised into HGM Units as in Figure 5-1. HGM Units are then assessed individually for habitat integrity.

The initial site investigation was undertaken in November 2013 for orientation and to assess wetland integrity during the wet-season. This time of year is ideal for field investigations, as it coincides with the flowering-time of many of the plant species that occur in wetlands and animals are also most active. This also coincides with the time recommended by the Mpumalanga Parks and Tourism Agency (MPTA). An additional site visit was conducted in April 2014 in order to confirm the boundaries of wetlands on site. The site visit included a concise evaluation of the current impacts on the wetland habitat on site, as well as the features that contribute to ecological integrity and functionality.

Floodplain		Valley bottom areas with a well-defined stream channel stream channel, gently sloped and characterised by floodplain features such as oxbow depression and natural levees and the alluvial (by water) transport and deposition of sediment , usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterised by the net loss of sediment. Water inputs from the main channel (when channel banks overspill) and from adjacent slopes.

Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel, usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from the channel entering the wetland and also from adjacent slopes.
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterised by colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly to a stream channel.
Isolated hillslope seepage		Slopes on hillsides that are characterised by colluvial transport (transported by gravity) movement of materials. Water inputs are from sub-surface flow and outflow either very limited or through diffuse sub-surface flow but with no direct link to a surface water channel.
Pan/Depression		A basin-shaped area with a closed elevation contour that allows for the accumulation of surface water (ie. It is inward draining). It may also receive subsurface water. An outlet is usually absent and so this type of wetland is usually isolated from the stream network.

Figure 5-1: Wetland HGM Units (modified from Brinson 1993; Kotze 1999 and Marneweck and Batchelor 2002)

5.2. Wetland Delineation

In accordance with the DWAF guidelines (DWAF 2005) the wetland delineation procedure considers four attributes to determine the limitations of the wetland. These attributes are discussed according to the DWAF guidelines in further detail later on in this section. Further descriptions on the four attributes are presented in Appendix B. The four attributes are:

- Terrain Unit Indicator – helps to identify those parts of the landscape where wetlands are more likely to occur;
- Soil Form Indicator – identifies the soil forms, which are associated with prolonged and frequent saturation;
- Soil Wetness Indicator – identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation; and
- Vegetation Indicator – identifies hydrophilic vegetation associated with frequently saturated soils.

In accordance with the definition of a wetland in the NWA, vegetation is the primary indicator of a wetland, which must be present under normal circumstances; however, the soil wetness indicator tends to be the most important in practice. The remaining three indicators are then used in a confirmatory role. The reason for this, is that the response of vegetation to changes in the soil moisture regime or management are relatively quick and may be transformed, whereas the morphological indicators in the soil are significantly more permanent and will hold the indications of frequent and prolonged saturation long after a wetland has been drained (perhaps several centuries) (DWAF 2005).

5.3. Wetland Ecological Health Assessment

A PES analysis was conducted to establish baseline integrity (health) for the associated wetlands. In order to determine the integrity (health) of the characterized HGM units for the project area, the WET-Health tool was applied. According to Macfarlane *et al.* (2007) the health of a wetland can be defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. The health assessment attempts to evaluate the hydrological, geomorphological and vegetation health in three separate modules in order to attempt to estimate similarity to or deviation from natural conditions. The Present Ecological State (PES) is determined according to Table 5-1.

Table 5-1: Impact scores and Present Ecological State categories used by WET-Health

Description	Combined Impact Score	PES Category
Unmodified, natural.	0-0.9	A
Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota has taken place.	1-1.9	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable.	6-7.9	E
Modifications have reached a critical level and ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

5.4. Wetland Ecological Importance and Functionality Assessment

In order to assess the importance of wetlands identified on site from an ecological perspective, taking into account aspects related solely to the maintenance of ecological diversity and functionality, the EIS tool was used. For this methodology, a series of determinants are assessed using a ranking scale of 0-4 (Table 4-2), from which the median of each determinant is used to allocate an ecological management class.

Table 5-2: Criteria used for determining the EIS of wetlands

Primary determinants
1. Rare & Endangered Species
2. Populations of Unique Species
3. Species/taxon Richness
4. Diversity of Habitat Types or Features
5 Migration route/breeding and feeding site for wetland species
6. Sensitivity to Changes in the Natural Hydrological Regime
7. Sensitivity to Water Quality Changes
8. Flood Storage, Energy Dissipation & Particulate/Element Removal
Modifying determinants
9. Protected Status
10. Ecological Integrity

5.5. Wetland Functional Assessment

The onsite wetlands were grouped according to homogeneity and assessed utilising the functional assessment technique, WET-EcoServices, developed by Kotze *et al.* (2007) to provide an indication of the benefits and services. As a result of this, scores are not wetland area specific but do however provide an indication of the ecological services offered by the different wetland systems as a whole for this project area.

5.6. Impact Assessment

The impacts of the development and operation of the proposed underground coal mining project on the receiving wetlands areas within the project area were assessed at different stages of the development of the mine according to the methodology indicated in Table 5-2.

A clearly defined rating scale is used to assess each impact in terms of severity, spatial extent and duration (which determines the consequence) and in terms of the frequency of the activity and the frequency of the related impact (which determines the likelihood of occurrence). The overall impact significance, is then determined via a significance rating matrix (Table 5-3) utilising the scores obtained for consequence and likelihood of occurrence, in order to assign a final impact rating.

Table 5-3: Impact Assessment methodology

Rating	Severity	Spatial scale	Duration	Probability

Rating	Severity	Spatial scale	Duration	Probability
7	Very significant impact on the environment. Irreparable damage to highly valued species, habitat or eco system. Persistent severe damage.	International The effect will occur across international borders	Permanent: No Mitigation No mitigation measures of natural process will reduce the impact after implementation.	Certain/ Definite. The impact will occur regardless of the implementation of any preventative or corrective actions.
6	Significant impact on highly valued species, habitat or ecosystem.	National Will affect the entire country	Permanent: Mitigation Mitigation measures of natural process will reduce the impact.	Almost certain/Highly probable It is most likely that the impact will occur.
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate	Province/ Region Will affect the entire province or region	Project Life The impact will cease after the operational life span of the project.	Likely The impact may occur.
4	Serious medium term environmental effects. Environmental damage can be reversed in less than a year	Municipal Area Will affect the whole municipal area	Long term 6-15 years	Probable Has occurred here or elsewhere and could therefore occur.
3	Moderate, short-term effects but not affecting ecosystem functions. Rehabilitation requires intervention of external specialists and can be done in less than a month.	Local Local extending only as far as the development site area	Medium term 1-5 years	Unlikely Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur.

Rating	Severity	Spatial scale	Duration	Probability
2	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants.	Limited Limited to the site and its immediate surroundings	Short term Less than 1 year	Rare/ improbable Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures
1	Limited damage to minimal area of low significance, (e.g. ad hoc spills within plant area). Will have no impact on the environment.	Very limited Limited to specific isolated parts of the site.	Immediate Less than 1 month	Highly unlikely/None Expected never to happen.

5.7. Study Limitations

- The wetland delineation is based on sample data obtained from transects taken at selected points along HGM units. This data is then extrapolated in order to represent the entire HGM unit. Although every effort is made to ensure accuracy as far as possible, the wetland delineation represented in this report may differ marginally from the reality in some instances, and;
- It is also imperative to note that any changes to the wetlands systems within the study boundary after field work had commenced were not considered for this assessment. Any discrepancies as a result of this have not been regarded.

6. STUDY AREA

The study area is located north of the town Evander and south of the town Kriel on the farms: Langsloot 99 IS, Dieplaagte 123 IS, Wildebeestfontein 122 IS, Rietfontein 100 IS, Rietfontein 101 IS, Zondagsfontein 124 IS, Zondagskraal 125 IS and Vaalbank 96 IS, in the Mpumalanga Province (as indicated in **Figure 6-1**). This area is part of the Highveld Coalfields and is located in the Eastern Highveld Grassland and Soweto Highveld Grassland vegetation types. Soils in the region are generally deep and reddish. The dominant soil forms on site include: Arcadia (Ar), Swartland (Sw), Mayo (My), Valsrivier (Va) and Mispah (Ms) (refer to Soils EIA-phase Report by Digby Wells, 2014). None of these soils are regarded as wetland soils as such but additional forms may occur on site.

The average annual high temperature is 21°C and the average low temperature is 8°C in the vicinity of Evander. The highest recorded rainfall occurs from November to January with an average of 117 mm in January. The average rainfall for November, during the initial sampling visit, was 117mm and 24mm during the second visit in April 2014. In addition to the suitability of the time of year, rainfall was sufficient for the emergence of wetland plant species.

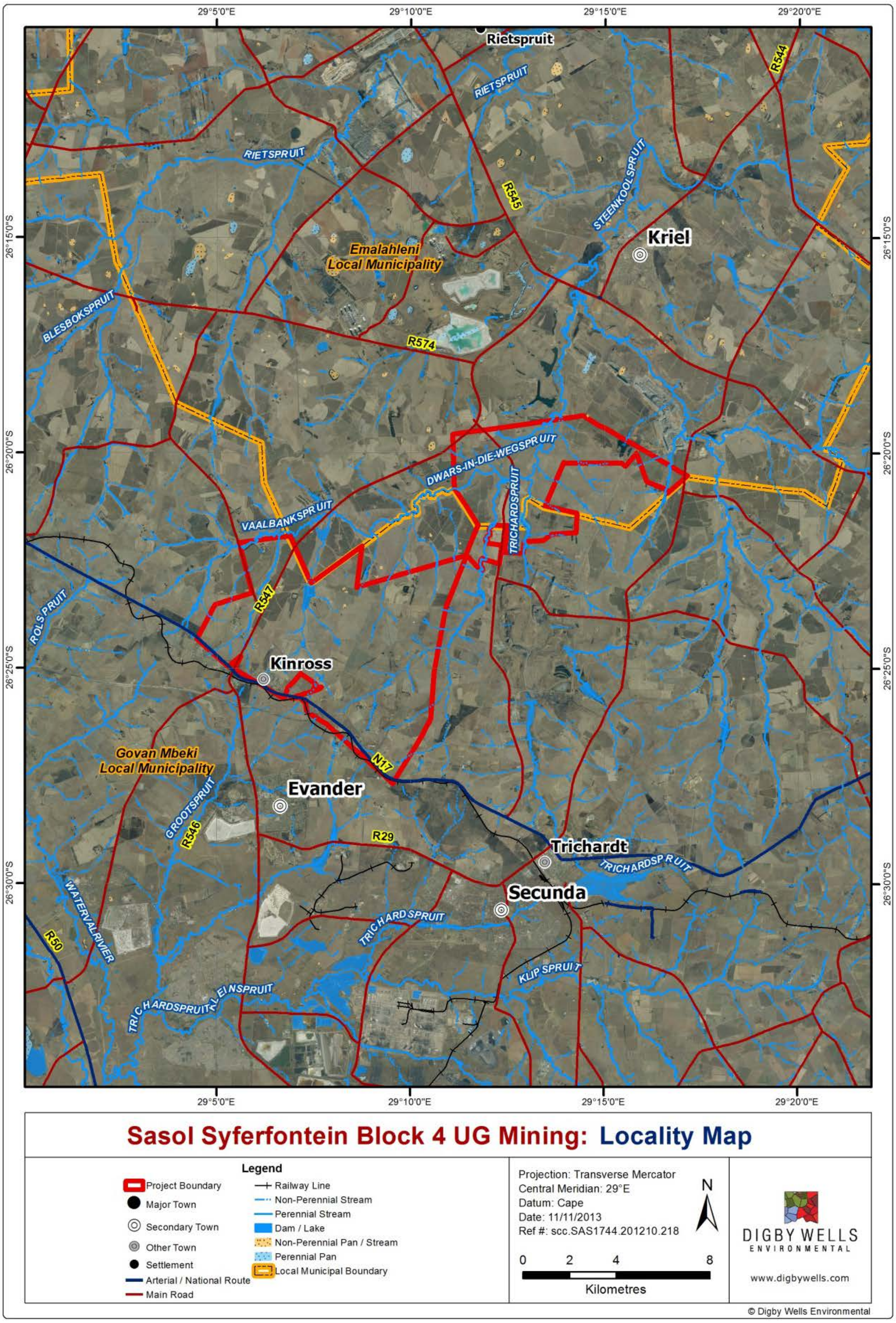

Figure 6-1: Syferfontein study area in relation to the regional setting

6.1. Drainage and Quaternary Catchments

The majority of the study area falls within the quaternary catchment B11D, with a portion to the east falling within B11C (Figure 6-2.). This catchment has been allocated an overall ecological state of Low to Marginal based on medium confidence (Kleynhans, 2000). B11D falls within the Upper Olifants River Catchment and the major surface water drainage systems associated with the study area include: Dwars-in-die-wegspruit; Grootspruit; Trichardspruit and Vaalbankspruit. The Upper Olifants River Catchment forms part of 18 of the strategic water management areas in South Africa (Mey and van Niekerk 2009). Coal mining is concentrated in the upper portion of this catchment and has historically contributed to poor water quality through direct contamination of streams and rivers.

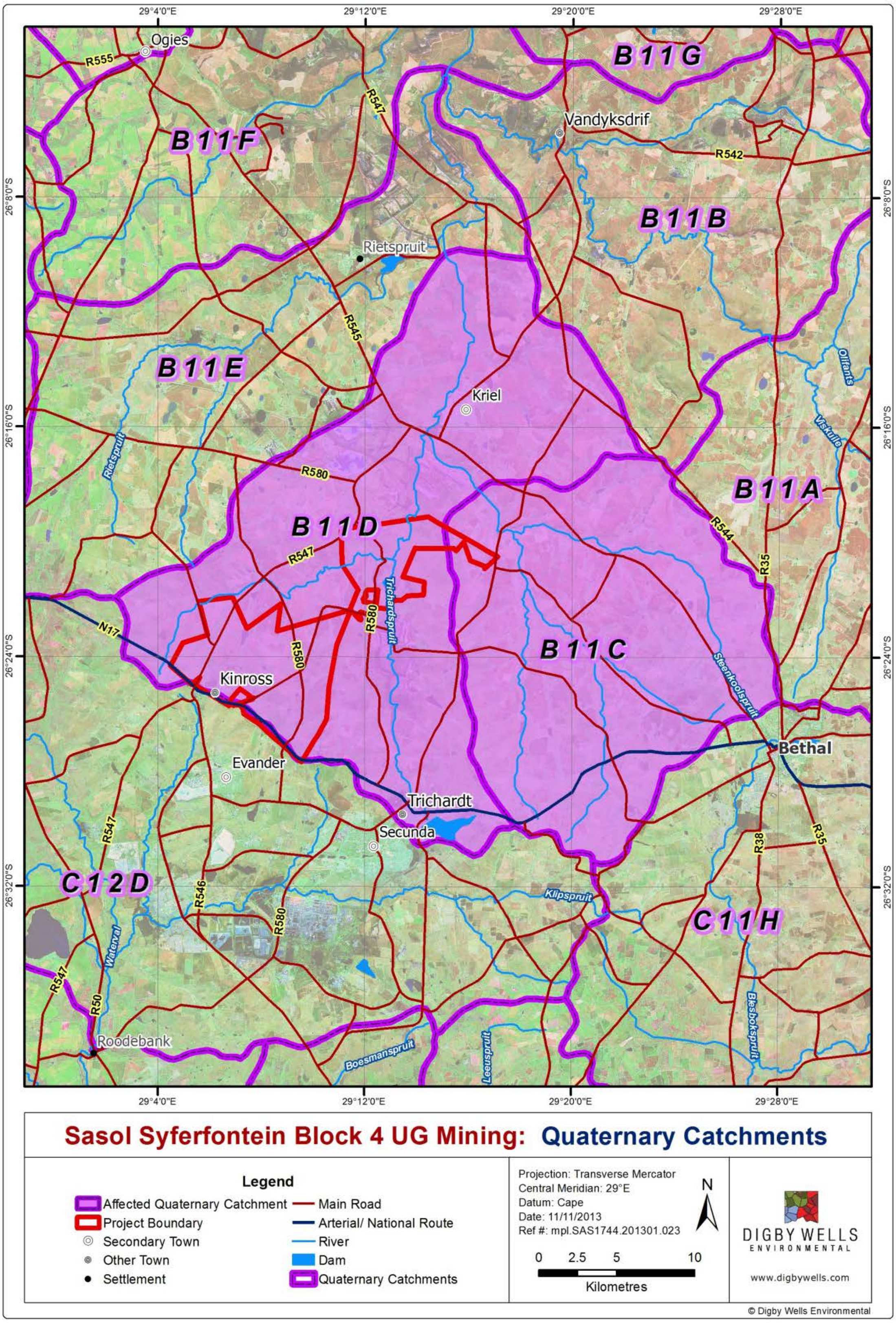

Figure 6-2: Syferfontein study area in relation to the quaternary catchments

6.2. National Freshwater Ecosystems Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) strategic spatial priorities for conserving the country's freshwater ecosystems and supporting sustainable use of water resources were considered to evaluate the importance of the wetland areas located within the Syferfontein underground coal mining project area (Nel *et al.* 2011).

Spatial layers (FEPA's) used include the wetland classification and ranking. Figure 6-3 illustrates the different wetland types recorded according to NFEPA. The identified wetland areas play important functions such as the enhancement of water quality, attenuation of floods and biodiversity support.

The NFEPA wetlands have been ranked in terms of importance in the conservation of biodiversity. Table 6-1 below indicates the criteria which were considered for the ranking of wetland areas. The majority of wetlands identified by NFEPA for Syferfontein were allocated a ranking of six, which indicates that some of them have been incorporated into the Working for Wetlands program.

Table 6-1: NFEPA wetland classification ranking criteria

Criteria	Rank
Wetlands that intersect with a RAMSAR site.	1
Wetlands within 500 m of an IUCN threatened frog point locality; Wetlands within 500 m of a threatened waterbird point locality; Wetlands (excluding dams) with the majority of their area within a sub-quaternary catchment that has sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes; Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of exceptional Biodiversity importance, with valid reasons documented; and Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands that are good, intact examples from which to choose.	2
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing wetlands of biodiversity importance, but with no valid reasons documented.	3
Wetlands (excluding dams) in A or B condition AND associated with more than three other wetlands (both riverine and non-riverine wetlands were assessed for this criterion); and Wetlands in C condition AND associated with more than three other wetlands (both riverine and non-riverine wetlands were assessed for this criterion).	4
Wetlands (excluding dams) within a sub-quaternary catchment identified by experts at the regional review workshops as containing Impacted Working for Wetland sites.	5
Any other wetland (excluding dams).	6

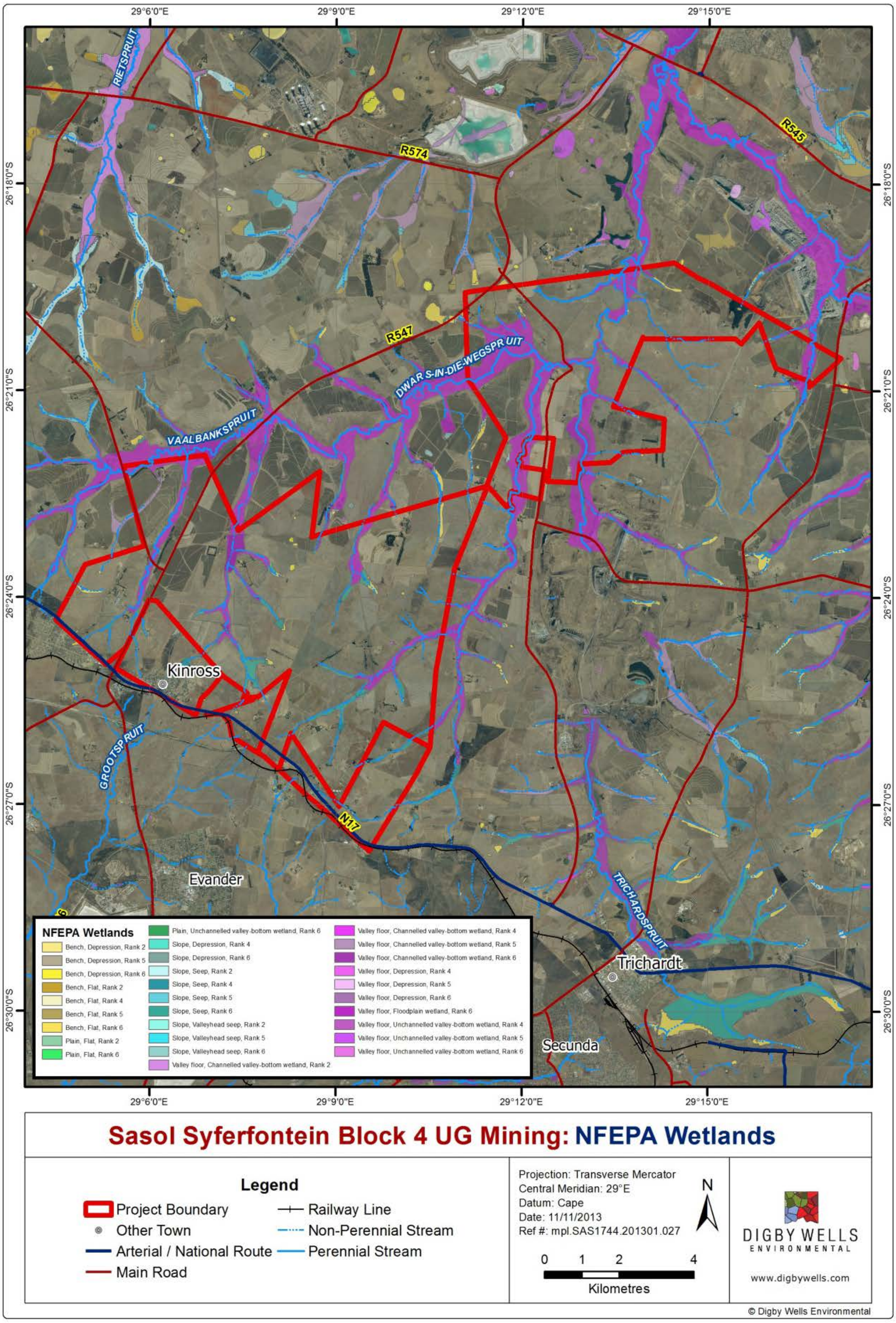

Figure 6-3: Syferfontein study area in relation to the NFEPA wetlands

6.3. Mpumalanga Biodiversity Conservation Plan

The Mpumalanga Biodiversity Conservation Plan (MBCP) is a plan developed conjointly by the Mpumalanga Tourism and Parks Agency (MPTA) and Department of Agriculture and land Administration (DALA) to guide conservation and land-use decisions in the province in order to support sustainable development. The MPTA recognises that wetlands are specialised systems that perform ecological functions that are crucial for human and environmental welfare. According to the MBCP, the wetlands in the study area are regarded as 'not required', which implies that wetlands here have not been allocated any particular significance for meeting their requirements (Figure 6-4). It is imperative to note that the desktop findings may differ from the actual results from field studies. The current impacts on wetlands in the Syferfontein site are discussed in Section 7.3.

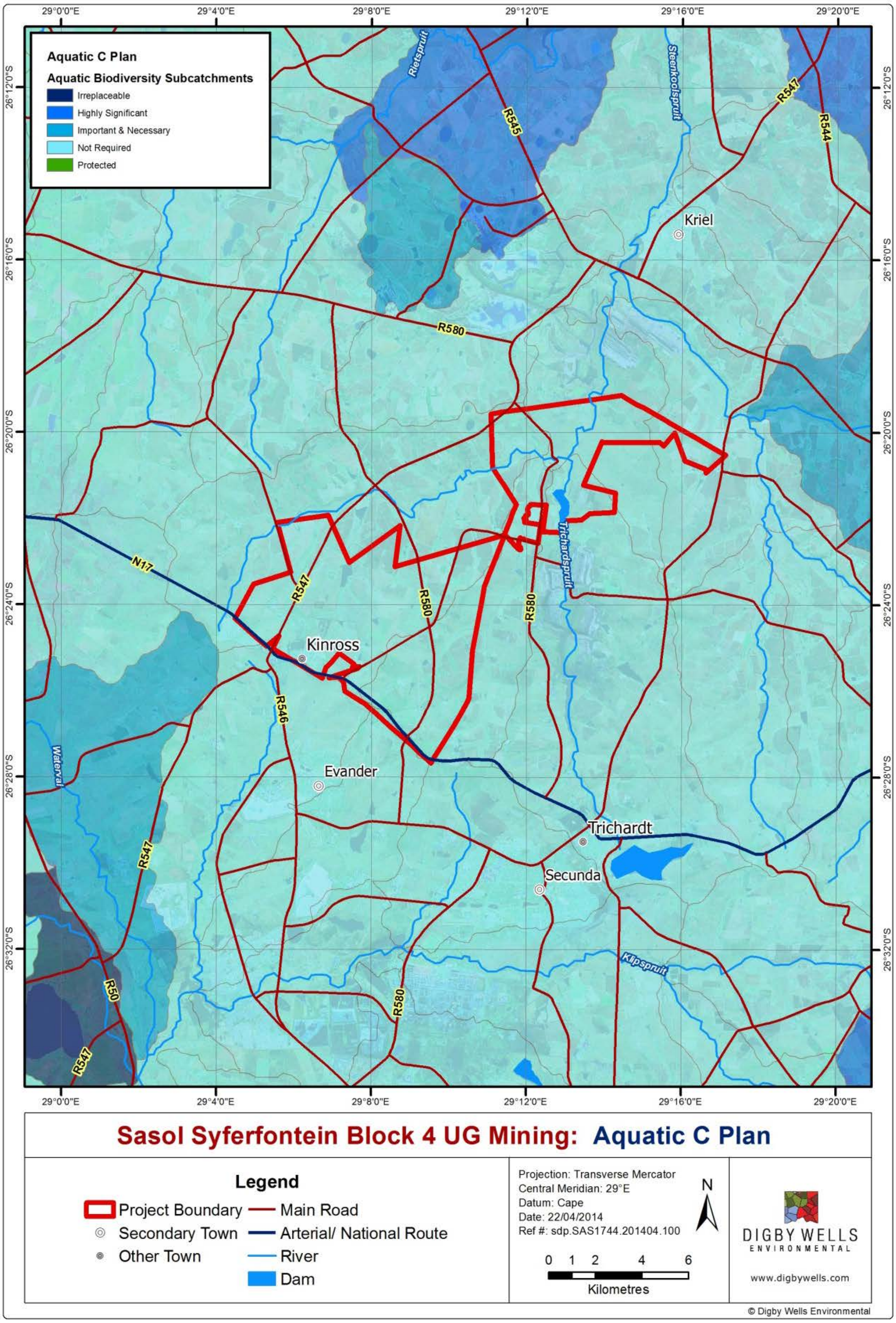

Figure 6-4: Mpumalanga C-plan

7. WETLAND ASSESSMENT FINDINGS

7.1. Wetland delineation

The wetland delineation was completed with the aid of aerial imagery, as well as verification in the field and is represented in Figure 7-1. Figure 7-1 also represents the recommended buffers for protection around the wetlands on site. Although no surface infrastructure is proposed for this phase of the project, buffers should be regarded for any future planning. In addition, wetlands and buffer zones should be regarded as 'no-go' during construction.

The buffer zones are a requirement in order to facilitate the protection of the delineated wetland areas within the project area. The purpose of the establishment of buffer zones is to minimise the anthropogenic impacts associated with the proposed development on the receiving water resources. A buffer zone is defined as:

"*the strips of undeveloped, typically vegetated land (composed in many cases of riparian habitat or terrestrial plant communities) which separate development or adjacent land uses from aquatic ecosystems (rivers and wetlands).*"

A number of explanations have been provided for the establishment of buffer zones, some of the reasons are listed below:

- Reducing the impacts of adjacent land uses on water resource quality and the associated biodiversity, and;
- Sustaining or improving the ability of the water resources to provide goods and services to the current and future water end users within the catchment area.

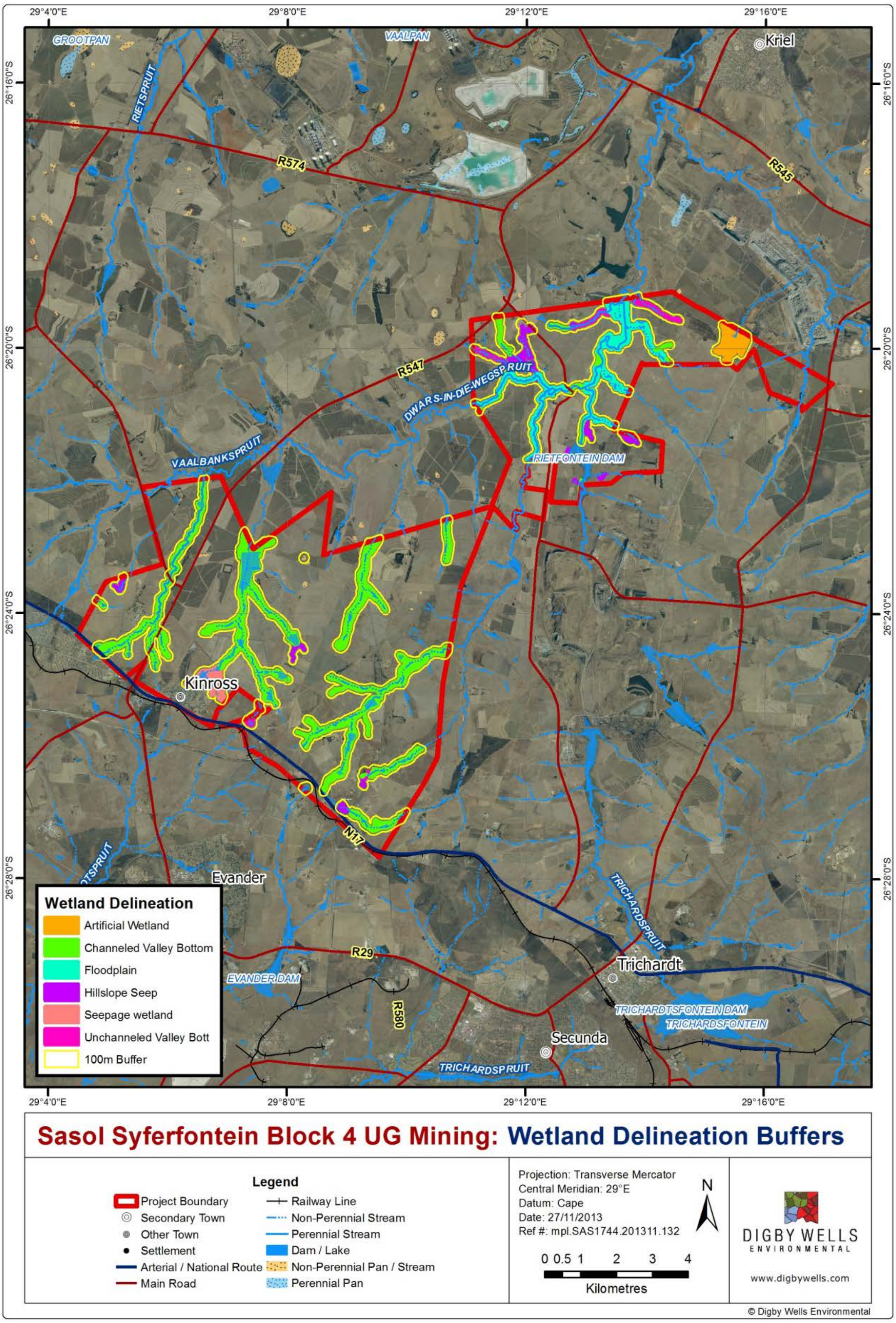

Figure 7-1: Wetland delineation with 100m buffer

7.2. Wetland Unit Identification

The majority of wetlands identified in the Syferfontein project area can be classified as channelled valley bottom wetlands linked to streams associated with the Dwars-in-die-wegspruit; Grootspruit; Trichardspruit and Vaalbankspruit. Based on the presence of seepage wetlands on site as well as valley bottom and pans systems, it can be deduced that the wetlands are linked to both surface and groundwater sources. This is typical of wetlands that occur across the landscape in Mpumalanga Province. Table 7-1 lists the areas of wetland HGM units identified on site and Figure 7-3 shows examples of these wetland HGM units. Figure 7-4 represents the distribution of the HGM units.

Table 7-1: Classification of wetlands into HGM units

HGM Unit	Area	% of total wetland area
Hillslope Seep	129.16	15
Pan / Depression	4.75	0.5
Artificial Wetland	52.31	6
Channeled Valley Bottom	511.76	58
Unchanneled Valley Bottom	31.67	4
Floodplain	156.48	17
Total	**881.38**	**100**

7.2.1. Description of HGM units identified on site

The general descriptions of the identified wetland HGM units associated with the underground mine area are described below:

Hillslope seeps	
	Hillslope seepage wetlands are usually associated with a perched groundwater table, where precipitation that occurs within the greater catchment is temporarily stored within the soil profile as a result of impervious strata in the soil profile. The impervious strata within the soil profile is normally made up of an unweathered parent material or swelling clays typically associated with granites, sandstones or shales. Hillslope seepage wetlands are expressed were the soil profile is shallow enough such that impervious layer and the water stored within the soil profile are expressed on the surface. The soils in the area must be waterlogged long enough for oxygen to be depleted through a chemical process of reduction which results in the presence of radoximorphic features in the soil. Hillslope seepage wetlands are created and maintained by infiltration processes that occur in the surrounding non-wetland areas within the catchment. Hillslope seepage wetlands connected to watercourses are wetland systems which are directly linked on the surface to watercourses. This type of system typically contributes to flow in the watercourses, even if this contribution is only on a seasonal basis.
Pan/ Depression	

Pans are shallow ephemeral systems that are a common feature of the landscape of Mpumalanga and generally occur over shales and unconsolidated surficial sandstones in South Africa (Allan *et al.* 1995). Their formation is dependent on a number of factors, including climate, geological susceptibility, disturbance to the surface via animals, salt-weathering, a lack of integrated drainage systems and deflation processes (Goudie and Thomas 1985). They are inward draining systems and as a result, their catchment is regarded as sensitive.

Floodplain

Floodplains occur in depressions and basins, often at drainage divides on top of the hills. Valley bottom areas without a stream channel gently sloped and characterised by floodplain features such as oxbow depressions and natural levees and the alluvial transport and deposition of sediment, usually leading to a net accumulation of sediment.

Valley Bottom Systems

Channelled Valley Bottom

According to Kotze *et al.* (2007), channelled valley bottom systems are characterised by less active deposition of sediment and an absence of oxbows and other floodplain features such as levees and meander scrolls. These wetland types tend to be narrower and have somewhat steeper gradients and the contribution from lateral groundwater input relative to the main stream channel is generally greater. The primary cause of this channelling is the result of erosion (Kotze *et al.* 2007).

Unchannelled Valley Bottom

The valley bottom wetlands without channels are located at the lowest position in a landscape where the water drained from the local slopes accumulate. Water expressed in the hillslope seepage wetlands may also drain towards the valley bottom wetlands. These wetland systems play important functions such as sediment trapping, flood attenuation and nutrient-cycling. The valley bottom without a channel wetland on site receives extensive amounts of sediment and flow from the surrounding cultivated slopes. This allows an opportunity for contact between solute-laiden water and the wetland vegetation, thus providing an opportunity for flood and contaminant (nutrients, pesticides, herbicides) attenuation. Extensive areas of these wetlands remain saturated as stream channel input is spread diffusely across the valley bottom, even at low flows (Kotze *et al.,* 2007). These wetlands also tend to have a high organic content.

	Facultative wetland indicator plant species, comprising a mixture of grasses and sedges are evident as longitudinal bands within a relatively narrow zone along the valley bottoms. Facultative wetland plant species usually grow in wetlands (67-99% of occurrences) but occasionally are found in non-wetland areas. Lateral seep zones form part of the adjacent hillslope seepage wetlands, this is a characteristic for all the valley bottom wetlands. The primary drivers for these systems, owing to the shallow gradients along the valley bottoms are diffuse horizontal surface flow and interflow. There is generally a clear distinction in the transition in the vegetation structure between the mixed grass-sedge meadow zones that characterise these wetlands to the more intermittently wet grassland habitats associated with the adjacent hillslope seepage wetlands (Kotze *et al*., 2007).

7.3. Wetland Integrity

The general features of the identified wetland units within the project area were assessed in terms of impacts on the integrity of these systems using the WET-health methodology. Wetlands that showed connectivity were grouped as two major 'wetland complexes' according to their relevant links to the major wetland systems in the area, namely the Vaalbankspruit and the Trichardspruit and Dwars-in-die-wegspruit. Pan / depressions were isolated and assessed separately, and were largely impacted by agriculture, wehre crops had infringed on pan habitat. The identified impacts include activities such as damming, increased hardened surfaces due to the presence of bridges and roads through wetlands (and associated culverts), alien plant species invasion and trampling by livestock (which promote the processes of erosion). Damming is the major impact on wetlands on site and constructed dams occur throughout the landscape. This is particularly the case for wetlands associated with the Vaalbankspruit complex, where dams were frequent and up to 2m high. The result is shortening and diversion of natural channels as well as the trapping of sediment. Sediment trapped in dams is critical for the maintenance of habitats and physical processes downstream. Furthermore, when the sediment load downstream is not replenished, erosional processes are promoted and the stream or river may become deeply incised.

Culverts, where roads cross wetlands, also contribute to the negative effects on wetlands on site. The natural diffuse nature of the water-flow through wetlands is altered, as culverts cause direct flow to occur, reducing the time for infiltration and promoting erosional processes. Table 7-2 represents the PES scores for the wetland HGM units identified on site. Examples of the negative impacts on wetland habitat integrity are represented in Figure 7-2 below.

Table 7-2: PES for wetland complexes on site

Wetland Complex	Module	Health Score	PES Class

Vaalbankspruit wetlands	*Hydrology*	6.5	E↓↓
	Geomorphology	4.3	D→
	Vegetation	5.5	D↓↓
	Overall Score	5.6	D↓↓
Trichardspruit and Dwars-in-die-wegspruit	*Hydrology*	6	E↓
	Geomorphology	2	C↓
	Vegetation	2.3	C↓
	Overall Score	3.8	C↓
Pan / Depressions	*Hydrology*	6	E↓
	Geomorphology	2	C↓
	Vegetation	2.3	C↓
	Overall Score	3.8	C↓

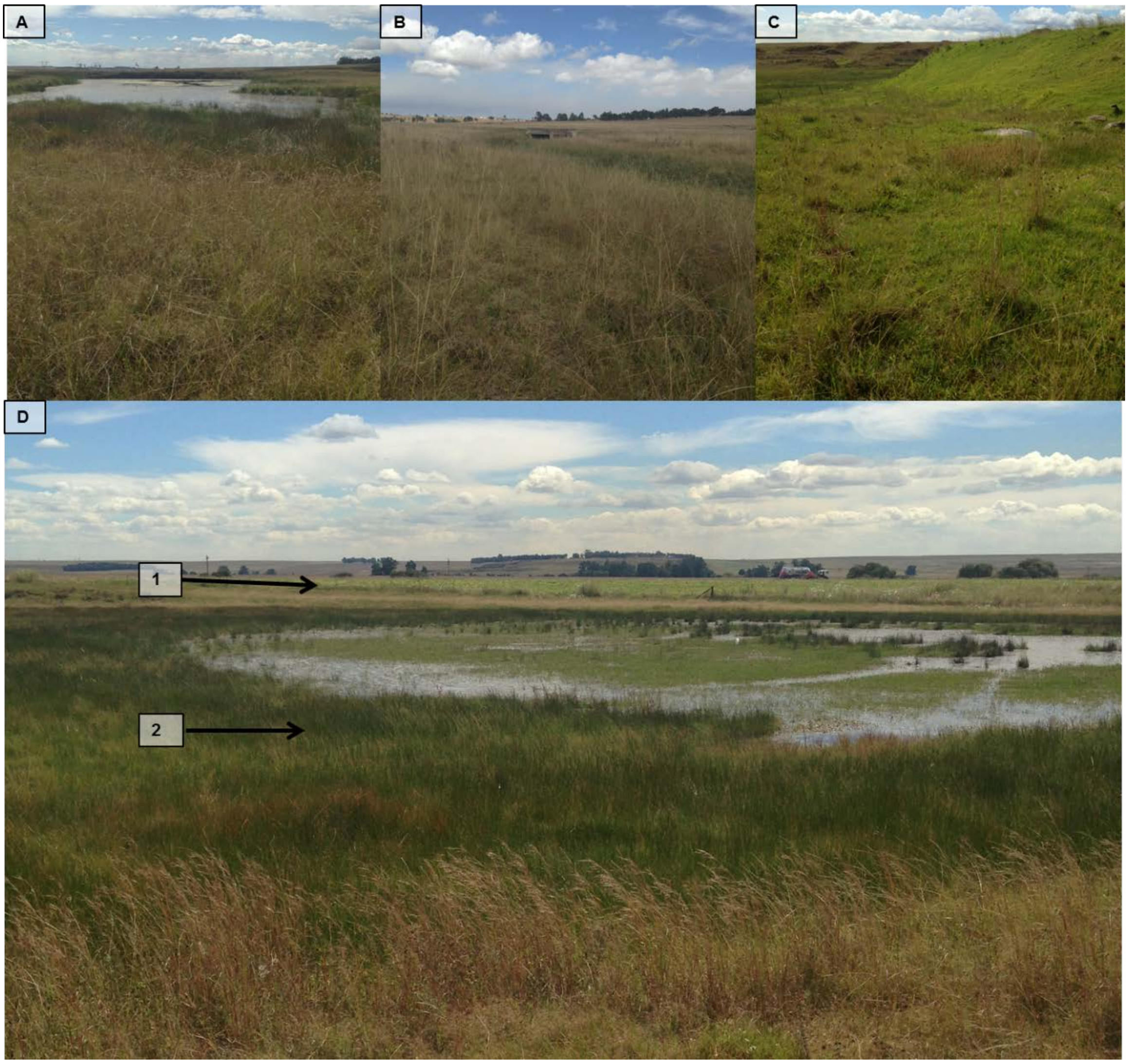

Figure 7-2: Examples of impacts on wetland habitat integrity (A: damning of a channelled valley bottom on the Vaalbankspruit system; B: culverts underneath the road of an unchanneled valley bottom; C: dam walls across wetlands were found to reach up to 2m in height (Trichardspruit and Dwars-in-die-wegspruit system) and D: soybean crops (1) infringing into the wetland habitat (2))

7.4. Wetland EcoServices

The general features of each wetland unit were assessed in terms of functioning and the overall importance of the HGM unit was then determined at a landscape level. The results from the WET-EcoServices tool for the respective wetland units are presented below in Figure 7-3; and highlight that wetlands on site generally provide services that are rated as Low to High. Pans were rated according to the following scale:

- <0.5 Low
- 0.5-1.2 Moderately Low
- 1.3-2.0 Intermediate

- 2.1-2.8 High
- >2.8 Very High

Valley bottom systems showed High scores for flood attenuation, nutrient processing and toxicant removal. Wetlands associated with the Vaalbankspruit system showed slightly higher scores than the Trichardspruit and Dwars-in-die-wegspruit wetlands for sediment trapping and nutrient processing. Pans scored High for sediment trapping, nutrient processing and erosion control.

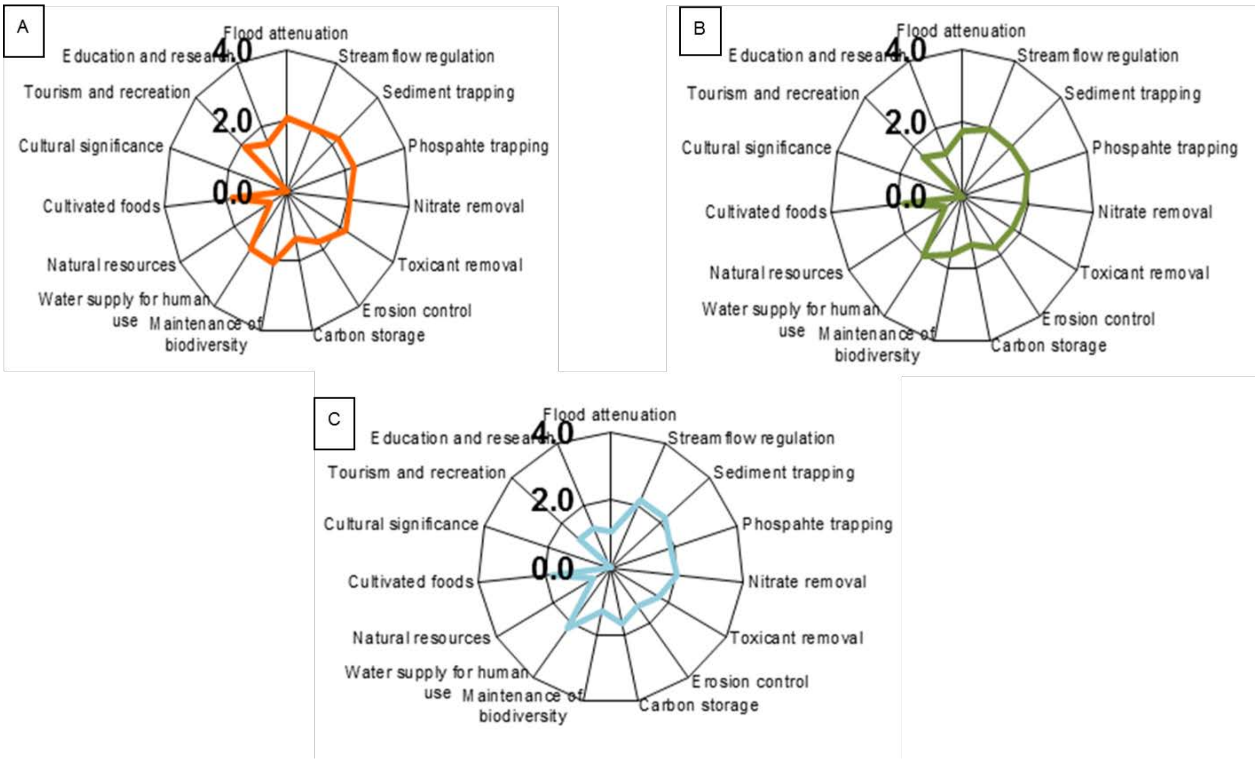

Figure 7-3: Radial plots of Eco-services provided by wetlands on site (A: Vaalbankspruit complex; B: Trichardspruit and Dwars-in-die-wegspruit complex and C: Pan / Depressions

7.5. Wetland Ecological Importance and Sensitivity (EIS)

The overall EIS was calculated for each HGM unit, as represented in Table 7-3. Hillslope seeps provided habitat for flora SSC (Figure 7-4) and also provide a natural water purification service. Owing to the connection between hillslope seeps and groundwater recharging aquifers, these HGM units are sensitive to changes in the hydrological regime.

Table 7-3: EIS scoring results for wetland HGM units

Score			
HGM Unit	**Hillslope Seep**	**Pan / Depression**	**Valley Bottom Systems**

Rare & Endangered Species	3	2	2
Populations of Unique Species	1	1	1
Species/taxon Richness	2	3	3
Diversity of Habitat Types or Features	3	3	2
Migration route/breeding and feeding site for wetland species	3	2	4
Sensitivity to Changes in the Natural Hydrological Regime	4	3	3
Sensitivity to Water Quality Changes	2	3	2
Flood Storage, Energy Dissipation & Particulate/Element Removal	4	1	3
Protected status	1	1	2
Ecological Integrity	3	2	2
Total	26	21	24
Median	3	2	2
Overall EIS	B	C	C

Figure 7-4: Examples of flora SSC found in wetland habitat on site (A: *Crinum bulbispermum* (provincially Protected and nationally Declining) found in and adjacent to wetland areas in the extension areas of the project and B: *Eucomis autumnalis* (Pineapple Flower), a provincially Protected geophyte found at wetland edges on site

8. IMPACT ASSESSMENT

The proposed underground coal mine is intended to mine Coal Seam No. 4 at a depth of approximately 60m below the surface using the bord and pillar mining method. No surface infrastructure is proposed for the Block 4 area as an adit in the highwall of the existing Syferfontein Colliery will be employed for entry. Further to this, the proposed Project will be served by existing infrastructure located on the Tweedraai mining area.

8.1. Assessment of the Current Impacts (No Go Option)

The current land-use activities within the study area are mainly maize (*Zea mays*) and soybean (*Glycine max*). Continued agricultural activities on site will result in transformation of wetlands and areas adjacent to wetlands to a disturbed state, thus reducing biodiversity. This will promote processes of erosion and reduce the capacity of wetlands to produce EcoServices such as nutrient cycling, water purification and flood attenuation. A loss of vegetation cover results in reduced surface roughness and and lowered infiltration of run-off. As a consequence, the formation of erosion gulleys and rills takes place, which can lead into wetland areas.

Issue 1: Direct loss of wetland areas

Loss of wetland areas has occurred within the project area as a result of crop farming. Soybean farms have encroached into the seepage areas and pan edges in order to maximise arable land area. As a result of the loss of wetland areas, the associated wetland vegetation has also been impacted.

- Impact 1: Direct loss of wetland areas;
- Impact 2: Loss of wetland vegetation.

Issue 1	**Direct loss of wetland areas**				
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 1	***Direct loss of wetland habitat***				
Pre- Mitigation	Significant Impact (7)	Municipal (3)	Permanent (6)	Certain (7)	High (120)
Post-Mitigation	N/A				
Impact 2	***Loss of Wetland vegetation***				
Pre- Mitigation	Very Serious (5)	Local (2)	Permanent (6)	Certain (7)	Medium-High (100)
Post-Mitigation	N/A				

Issue 2: Loss of wetland integrity and functionality

The application of agrochemicals and pesticides for the cultivation of soybeans and maize is likely to have resulted in contamination of water resources in the study area, which may have negative impacts on aquatic life and wetland-dependant plant and animal species.

- Impact 3: Contamination of surface water and loss of water quality improvement capacity

Issue 2	**Loss of Wetland integrity**				
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 3	***Contamination of surface water and loss of water quality improvement capacity***				
Pre- Mitigation	Very Serious (5)	Regional (5)	Permanent (6)	Likely (5)	Medium-High (75)
Post-Mitigation	N/A				

8.2. Impact of the underground mine construction and operation

The potential impacts of the proposed activity are discussed below.

Issue 1: Direct loss of wetland areas

Although the wetlands on site are not regarded as 'pristine' with regards to their PES values, further degradation of these systems should be avoided at all costs. As no surface infrastructure is anticipated for the proposed development, no direct loss of wetland habitat is expected. The potential for subsidence of unconsolidated surface sediments during the construction, operation and life of mine is however, a risk and is a commonly observed phenomenon due to underground mining. If surface subsidence occurs within wetland areas, a loss of wetland habitat as well as a loss of connectivity between wetland areas is likely to occur. A total of 263.77 ha of wetland habitat is underlain by proposed underground mining. The following impacts are expected for the direct loss of wetlands:

- Impact 1: Loss of wetland habitat; and
- Impact 2: Loss of wetland vegetation

Proposed Mitigation

- It is highly recommended that a geotechnical report is submitted in order to quantify the risk of subsidence, stipulate specifications for the bord and methods to be followed as well as to supply a suitable Safety Factor (SF).

Issue 1	**Direct loss of wetland areas**				
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 1	***Loss of wetland habitat***				
Construction Phase					

Issue 1	**Direct loss of wetland areas**				
Pre-mitigation	Limited (1)	Very limited (1)	Project life (5)	Unlikely (1)	Low (1)
Post-mitigation	Limited (1)	Very limited (1)	Project life (5)	Unlikely (2)	Low (14)
Operation Phase					
Pre-mitigation	Moderate (3)	Local (3)	Project life (5)	Probable (4)	Medium-Low (44)
Post-mitigation	Limited (1)	Very limited (1)	Project life (5)	Unlikely (2)	Low (14)
Impact 2	***Loss of Wetland vegetation***				
Construction Phase					
Pre-mitigation	Limited (1)	Very limited (1)	Project life (5)	Unlikely (1)	Low (1)
Post-mitigation	Limited (1)	Very limited (1)	Project life (5)	Unlikely (2)	Low (14)
Operation Phase					
Pre-mitigation	Moderate (3)	Local (3)	Project life (5)	Probable (4)	Medium-Low (44)
Post-mitigation	Limited (1)	Very limited (1)	Project life (5)	Unlikely (2)	Low (14)

Issue 2: Loss of wetland integrity

The following risks exist if there is a loss of wetland integrity due to subsidence:

- Impact 3: Loss of sensitive species.

No contamination of surface water is anticipated for the construction of the proposed underground mine.

Proposed mitigation

- All mitigation measures outlined in Issue 1 apply.

Issue 2: Loss of wetland integrity					
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 3:	***Loss of sensitive species***				
Construction Phase					
N/A					
Operational Phase					
Pre- Mitigation	Moderate (3)	Local (3)	Project life (5)	Probable (4)	Medium-Low (44)
Post-mitigation	Limited (1)	Very limited (1)	Project life (5)	Unlikely (2)	Low (14)

8.3. Cumulative impacts

If the risk of subsidence of unconsolidated sediments underlying wetlands is avoided, via proper management and adherence to the specifications of a geotechnical report, the proposed activity may be regarded as an insignificant contributor to the cumulative impacts on the water resources in the greater study area. Owing to the existing pressure on the water resources in the Upper Olifants catchment, however, the cumulative impacts of the proposed activity may be regarded as significant if subsidence is likely to occur. Wetlands are complex, interlinking systems and should be regarded on a large ecosystem-scale.

9. DISCUSSION

Wetlands in the Syferfontein Block 4 study area are largely linked to streams associated with the Dwars-in-die-wegspruit; Grootspruit; Trichardspruit and Vaalbankspruit tributaries and fall within the quaternary catchment B11D. This catchment coincides with the Upper Olifants River Water Management Area and has been assigned a general ecological state of ‘C’ – Low to Marginal.

The wetland areas on site are regarded as ‘not required’ according to the Mpumalanga C-Plan, which implies that they are not necessary for meeting the requirements of C-plan. Although small areas of seepage wetland were allocated a rank of two by NFEPA, indicating that they are considered as important for the maintenance of biodiversity, the majority of the wetlands on site were ranked six (which includes all ‘other’ wetlands not highlighted for their national importance). This may be attributable to the extensive crop farming in the study region, in proximity to and within wetlands, which reduces their value to society and for biodiversity.

Wetlands were delineated using the four indicators prescribed by DWAF (2005) and were found to cover an area of 881.38 ha. Four HGM units were identified on site, the majority belonging to the channelled valley bottom wetland type. Pan / depressions comprised 0.5% of the study area and were found to be largely altered due to the expansion of soybean crops in their catchments.

For the integrity and functionality assessment, wetlands that showed connectivity were grouped into two complexes according to their link to their respective major watercourses, namely: the Vaalbankspruit system and the Trichardspruit and Dwars-in-die-wegspruit. The frequency and scale of dams in the Vaalbankspruit complex has caused a significant alteration to the natural state of wetlands associated with the parent watercourses. The Trichardspruit and Dwars-in-die-wegspruit complex had also undergone extensive damming to a lesser extent. The impacts of damming are considerable with regards to geomorphology and hydrology and result in stream channel shortening, diversion as well as promoting the onset of erosional processes. With increased erosion, the floor of channels may become deeply incised and without regular replenishment of sediment sources, physical processes and habitat downstream may be negatively affected. Pans were regarded as separate entities, owing to their isolation from other HGM units.

10. CONCLUSIONS

Based on the low-risk nature of the proposed underground mining project, as well as the fact that less than 10% of the site is comprised of wetlands, it can be deduced that the overall impacts of the Syferfontein underground coal mine on wetland habitat is expected to be minimal.

If the underground mining of Block 4 and the additional expansion areas is to commence, efforts should be made to minimise or eliminate impacts on the wetland systems identified. Although no surface infrastructure is planned for this phase as yet, the main potential risk of underground mining is subsidence. It is recommended that geotechnical investigations are put in process in order to quantify this risk and that if the risk is likely, development be kept away from areas underlying wetland habitat. A preliminary Safety Factor of (>2) is recommended.

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Appendix A: CV's of the Specialists

Ms Crystal Rowe

Flora and Fauna Ecologist and Wetland Specialist

Biophysical Department

Digby Wells Environmental

EDUCATION

2012: Certificate of Competance to apply tools for wetland assessment – Rhodes University

2011: BSc Honours (Botany) – Nelson Mandela Metropolitan University

2008-2001: Undergraduate BSc – Nelson Mandela Metropolitan University

EMPLOYMENT

June 2013 – Present: Digby Wells Environmental

December 2011 – June 2013: Natural Scientific Services CC

EXPERIENCE

June 2013 – Present: Digby Wells Environmental

Crystal was appointed by Digby Wells Environmental chiefly as a Flora and Fauna Ecologist but also to assist in conducting wetland assessment studies. Crystal's flora background aids in her understanding on wetlands from a floral perspective. The wetland assessment studies include in particular the delineation of wetland boundaries, classification of wetland units according to the HGM Classification System, integrity description of the identified wetland units, functional assessment of the identified wetland units and subsequent compilation of management recommendations mitigation against the impacts. In addition, Crystal has also completed a course in Tools for Wetland Assessments at Rhodes University (2011).

December 2011 – June 2013: Natural Scientific Services CC

Field work and report compilation for Biodiversity Baseline Assessments, Wetland Assessments (WA) and Impact Assessments (IA).

PROJECT EXPERIENCE

Wetland Assessments

- Wetland assessment for Grootpan, Mpumalanga;
- Wetland assessment for Dube Tradeport, Kwa-Zulu Natal;
- Wetland assessment for Yzermyn in the Wakkerstroom area, Kwa-Zulu Natal;
- Wetland studies in Northern Mozambique, and;
- Wetland studies in Sierra Leone.

Appendix B: Wetland Delineation Methodology

WETLAND DELINEATION

In accordance with the definition of a wetland in the National Water Act (NWA), vegetation is the primary indicator of a wetland, which must be present under normal circumstances. However, the soil wetness indicator tends to be the most important in practices. The remaining three indicators are then used in a confirmatory role. The reason for this is that the response of vegetation to changes in the soil moisture regime or management are relatively quick and may be transformed, whereas the morphological indicators in the soil are significantly more permanent and will hold the indications of frequent and prolonged saturation long after a wetland has been drained (perhaps several centuries) (DWAF, 2005). In accordance with DWAF guidelines (2005) the wetland delineation procedure considers four attributes to determine the limitations of the wetland. The four attributes are:

Terrain Unit Indicator

Terrain Unit Indicator (TUI) areas include depressions and channels where water would be most likely to accumulate. These areas are determined with the aid of topographical maps, aerial photographs and engineering and town planning diagrams (these are most often used as they offer the highest degree of detail needed to accurately delineate the various zones of the wetland) (DWAF, 2005).

Soil Form Indicator

Hydomorphic soils are taken into account for the Soil Form Indicator (SFI) which will display unique characteristics resulting from prolonged and repeated water saturation (DWAF, 2005). The continued saturation of the soils results in the soils becoming anaerobic and thus resulting in a change of the chemical characteristics of the soil. Iron and manganese are two soil components which are insoluble under aerobic conditions and become soluble when the soil becomes anaerobic and thus begin to leach out into the soil profile. Iron is one of the most abundant elements in soils and is responsible for the red and brown colours of many soils. Resulting from the prolonged anaerobic conditions, iron is dissolved out of the soil, and the soil matrix is left a greying, greenish or bluish colour, and is said to be “gleyed”. Common in wetlands which are seasonally or temporarily saturated is a fluctuating water table, these results in alternation between aerobic and anaerobic conditions in the soil (DWAF, 2005). Iron will return to an insoluble state in aerobic conditions which will result in deposits in the form of patches or mottles within the soil. Recurrence of this cycle of wetting and drying over many decades concentrates these insoluble iron compounds. Thus, soil that is gleyed and has many mottles may be interpreted as indicating a zone that is seasonally of temporarily saturated (DWAF, 2005).

Soil Wetness Indicator

In practice, the Soil Wetness Indictor (SWI) is used as the primary indicator (DWAF, 2005). Hydromorphic soils are often identified by the colours of various soil components. The frequency and duration of the soil saturation periods strongly influences the colours of these components. Grey colours become more prominent in the soil matrix the higher the duration and frequency of saturation in a soil profile (DWAF, 2005). A feature of hydromorphic soils are coloured mottles which are usually absent in permanently saturated soils and are most prominent in seasonally saturated soils, and are less abundant in temporarily saturated soils (DWAF, 2005). In order for a soil horizon to qualify as having signs of wetness in the temporary, seasonal or permanent zones, a grey soil matrix and/or mottles must be present.

Vegetation Indicator

If vegetation was to be used as a primary indicator, undisturbed conditions and expert knowledge are required (DWAF, 2005). Due to this uncertainty, greater emphasis is often placed on the SWI to delineated wetland areas. In this assessment the SWI has been relied upon to delineated wetland areas in addition, the identification of indicator vegetation species and the use of plant community structures has been used to validate these boundaries. As one moves along the wetness gradient from the centre of the wetland to the edge, and into adjacent terrestrial areas plant communities undergo distinct changes in species composition. Valuable information for determining the wetland boundary and wetness zone is derived from the change in species composition. When using vegetation indicators for delineation, emphasis is placed on the group of species that dominate the plant community, rather than on individual indicator species (DWAF, 2005).

The Health Of Wetlands

Appendix B - Table 11-1: Health categories used by WET-Health for describing the integrity of wetlands

Description	Score	Category
Unmodified, natural	0 – 1	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	1.1 – 2	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2.1 – 4	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4.1 - 6	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6.1 – 8	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8.1 – 10	F