WETLAND DELINEATION

WETLANDS AND AQUATIC ECOSYSTEMS ASSOCIATED WITH WELTEVREDEN, BELFAST, MPUMALANGA.

NORTHERN COAL (PTY) LTD

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EXECUTIVE SUMMARY

Digby Wells & Associates (DWA) was appointed by Northern Coal to undertake a wetland study on the farm Weltevreden in the Belfast area, Mpumalanga. Information generated from this survey would be used to delineate, classify and map the wetlands at Weltevreden.

The objective of the wetland assessment was to delineate the wetland areas associated with the study area. The tasks which were adopted to meet the objective include a field investigation and a general descriptions of the wetland functioning.

A practical field procedure for identification and delineation of wetlands and riparian areas (DWAF, 2005) was used for this study. This described procedure identifies those parts of the landscape where wetlands are more likely to occur, identifies the soil forms, which are associated with prolonged and frequent saturation, identifies the morphological “signatures” developed in the soil profile and identifies hydrophilic vegetation associated with frequently saturated soils.

Five HGM wetland types were identified for the study area. Dams form the main artificial wetland type within the study area and occupy approximately 4% of the study area. The largest wetland type within the study area is the valley bottom wetland without a channel, followed on by the hillslope seepage wetlands connected to a watercourse and then isolated hillslope seepage wetlands. The smallest wetland types within the study area are the pan and hillslope seepage wetland connected to the pan. Approximately 30% of the study area is occupied by wetlands.

The proposed mining area is at the origin of the wetland system and would therefore be a minor impact in terms of water quantity reporting to wetland systems further downstream as opposed to the mining area being downstream of the origin. There is little change in the natural drainage of the wetland system. In a post open cast mined landscape wetland rehabilitation is impractical due to the requirements to maintain a free draining area as well as maintain wetland function. In its own right, wetland rehabilitation is very difficult to achieve, thus the approach whereby an equivalent area to that being lost is rehabilitated elsewhere, seems most rational in terms of mitigation and/or rehabilitation at this stage.

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1 TERMS OF REFERENCE

Digby Wells & Associates (DWA) was appointed by Northern Coal to undertake a wetland study on the farm Weltevreden in the Belfast area, Mpumalanga. Information generated from this survey would be used to delineate, classify and map the wetlands at Weltevreden. The National Water Act 36 of 1998 is important in that it provides a framework to protect water resources against over exploitation and to ensure that there is water for social and economic development, human needs and to meet the needs of the aquatic environment. The Act recognises both wetlands and rivers as water resources and are both protected under the Act. This study addresses the following regulations and regulatory procedures of the South Africa Departments of Water Affairs and Forestry and the Department of Environmental Affairs and Tourism:

- Section 19 of the National Water Act (Act 36, 1998);
- Section 21 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); and
- Section 5 of the National Environmental Management Act (Act 108 of 1998).

2 INTRODUCTION

The general conservation status of freshwater ecosystems worldwide is poor and continues to decline at a rapid rate, with rivers and wetlands among the most threatened of all ecosystems (Vitousek *et al.*, 1997, Revenga *et al*., 2000). According to Moyle and Williams (1990) and Jensen *et al*. (1993) this decline is a result of severe alteration caused by human activities. With an ever increasing human population as well as economic development, an increase in the demand for water is inevitable, as well as an increase in pollution to freshwater ecosystems. The sectors which are responsible for this are the domestic, agricultural, recreational and industrial sectors as they all depend on fresh flowing water (Roux *et al*., 1996). According to Jungwirth *et al.* (2000) and Muhar *et al*. (2000) aquatic ecosystems are heavily degraded on a global level by these human activities and impacts. As a result it is important for both conservation and management of freshwater systems to determine which basic processes, functions and structures make up the ecological integrity of these ecosystems. In spite of the fact that conservation of biological diversity has been the main aim of conservation biology, the phrase “biological integrity” has formed the cornerstone of all these programs. The ability of a biological system to function and maintain itself in the face of changes in environmental conditions is referred to as biological or biotic integrity (Angemeier and Karr, 1994).

South Africa has a diverse assortment of natural resources which does not include water (Ashton, 2007). One of the primary reasons for the scarcity of our water resources is that the excessive human population growth and development has resulted in unbalancing the availability of and state of water resources locally and on a global scale (Davies & Day, 1998). Water resources in South Africa are currently considered to be finite which suggests that in South Africa as a result of the excessive use of water resources will result in a water shortage that will progress into a water crisis unless the adequate management actions are taken to address this area of concern (Davies & Day, 1998). There have been some significant changes over the past few years to the priorities and approaches to management of water resources in South Africa (Ashton *et. al*, 2005). Culmination in the promulgation of the Water Services Act (WSA: Republic of South Africa, 1997) and the National Water Act (NWA: Republic of South Africa, 1998) may be attributed to the process of reform of the policy on water resources and water services (Ashton *et. al*, 2005).

According to the National Water Act (Act 36 of 1998), a water resource is not only considered to be the water that can be extracted from a system and utilized but the entire water cycle. This includes evaporation, precipitation and entire aquatic ecosystem including the physical or structural aquatic habitats, the water, the aquatic biota, and the physical, chemical and ecological processes that link water, habitats and biota. The entire ecosystem is acknowledged as a life support system by the National Water Act. According to van Wyk *et al.* (2006) the “resource” is defined to include a water course, surface water, estuary and aquifer, on the understanding that a water course includes rivers and springs, the channels in which the water flows regularly or intermittently, wetlands, lakes and dams into or from which water flows, and where relevant, the banks and bed or the system. Basic human needs, societal well-being and economic growth and development are supported by river ecosystem goods and services. A range of processes which support human well-being are included as ecosystem services such as the maintenance of water quality, waste disposal as well as those services relating to recreational and spiritual needs (van Wyk *et al.,* 2006). The Act requires that sufficient water is to be reserved to maintain as well as sustain the ecological functioning of the country’s aquatic ecosystems which include rivers, wetlands, groundwater and estuarine systems. If the country’s water resources continue to be abused and deteriorate, this will result in an unavoidable loss of key ecosystem services that support social and economic development (Postel and Richter, 2003; Driver et al., 2005; MEA, 2005; Dudgeon et al., 2006; Dasgupta, 2007).

The diverse goods and services provided for by water resource are acknowledged by the National Water Act. This ingrains the democratic principles necessary to safeguard equity in access to these resources. The aim is that society should be able to use as well as protect an agreed upon suite of goods and services derived from the water resource. The water law provides for an integrated, adaptive process for water resource management. The optimal use of natural resources for sustainable economic activity is essential in developing countries (Howarth and Farber, 2002). Biodiversity is a vital component for maintaining ecological processes and thus in ensuring sustainability of the ecosystem goods and services which is vital for successful water resource management (MacKat *et al.,* 2004)

South Africa's National Biodiversity Strategy and Action Plan (DEAT, 2005) acknowledges that there is cause for significant concern due to the declining status of ecosystems that degradation of ecosystems leads to a reduction in ecosystem services. This may result in a reduced capacity to generate clean water and a loss of food production due to land degradation. The overall framework for environmental governance in South Africa has been created by South Africa's Constitution (Act 108 of 1996) by establishing the right to an environment that is not harmful to health and well-being, by balancing the right to have the environment protected with rights to valid social and economic development and by allocating environmental functions to a wide range of government agencies in all spheres and requiring co-operation between government agencies and spheres of government (DEAT, 2005). National legislation has been promulgated to govern national competencies, one of which is water (National Water Act).

Therefore the approach adopted within South Africa by freshwater surface ecosystem regulators to balance the use of aquatic ecosystems includes ascertaining the current state and or availability of ecosystem resources, allocating ecological, social and or economic values to the resource to enable the sustainable use and or protection of the resources. In this study the surface aquatic ecosystems associated with the proposed Northern Coal mining activity, consisting of the associated wetland areas as well as the Klein Komati River, have been addressed. The South African River Health Programme (RHP) primarily makes use of biological indicators (e.g. fish communities, riparian vegetation, aquatic invertebrate fauna) to assess the condition or health of river systems. These methodologies were developed for lotic systems (rivers and streams) and are not applicable to lentic ecosystems (dams, lakes, pans etc.). Due to the lentic nature of the system assessed, only a wetland assessment was conducted. The delineation of the wetland areas was done in accordance with the DWAF (2005) methodology.

Wetlands are highly susceptible to the degradation of quality and a reduction in quantity as a result of anthropogenic resource use activities, (Mitsch and Gosselink, 1993; Brinson, 1993; Bernaldez et al., 1993, Diederichs and Ellery, 2001). land-surface-development (Gibbs, 2000) and landscape-management (Kotze and Breen, 1994; Whitlow, 1992) practices that alter their hydrological regime impacting these systems (Winter and Llamas, 1993). Historically wetlands have been perceived to be wastelands (Maltby, 1986) and this has resulted in the exploitation, alteration and in many cases the complete destruction of these valuable ecosystems, with an accompanying loss of associated ecosystem goods and services (Begg, 1986). It is now acknowledged that these ecosystems perform functions making them invaluable to the management of both water quantity and quality, and as a result wetlands are regarded as integral components of catchment systems (Jewitt and Kotze, 2000; Dickens et al., 2003).

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The aim of the study is to delineate the associated wetland areas of the study area. The following tasks were identified in order to meet the project objectives:

- Conduct a desktop and field investigation of the wetlands within the study areas;
- Assess, classify, delineate and map the identified wetlands;
- Describe the general functions of the wetlands;
- Determine the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of the wetlands on site; and
- Provide a report with maps of wetlands, detailing all the information.

This report presents the approach adopted, the results of the approach as well as a discussion of the significance and relevance of the determined results. Additionally, management options have also been provided to protect and manage ecosystems and areas of ecological importance.

3 STUDY AREA

The study area is located to the south of the town of Belfast (Trigonometrical Survey Office, 1970). The area assessed included sections of the farm Weltevreden 381 JT. The majority of the area is currently used for agriculture including cultivated fields, planted pastures and livestock farming. The Water Management Area (WMA) for Weltevreden is the Komati Catchment. The affected watercourse is the Klein Komati River which flows into the Komati River.

4 EXPERTISE OF THE SPECIALIST

A curriculum vitae (CV) and declaration of independence is attached in Appendix A

5 AIMS AND OBJECTIVES

The aim for this component of the study was to delineate the associated wetland areas. The following tasks were identified in order to meet the project objectives:

- Conduct a desktop and field investigation of the wetlands within the study areas;
- Assess, classify, delineate and map the identified wetlands;
- Describe the general functions of the wetlands;
- Determine the Present Ecological State and Ecological Importance and Sensitivity of the wetlands on site; and
- Provide a report with maps of wetlands, detailing all the information.

6 METHODOLOGY

6.1 Wetland classification, delineation and mapping

Maps were generated from 1:50 000 topographic maps and aerial photographs, onto which the wetland boundaries were delineated. Each of the identified wetlands were classified according to their hydrogeomorphic (HGM) 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).

In accordance with DWAF guidelines (2005) the wetland delineation procedure takes the following attributes to determine the limitations of the wetland:

- 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 National Water Act, 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).

For the purpose of this study, wetlands are considered as those ecosystems defined by the National Water Act 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."

A site visit was undertaken in July 2008 for orientation as well as for the purpose of field verification. According to Kotze and Marneweck (1999) soil augering was conducted to identify indicators of hydric conditions so as to verify whether or not the areas delineated as wetlands met the criteria for classification as wetlands.

6.1.1 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).

6.1.2 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).

6.1.3 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.

6.1.4 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).

6.2 Wetland functional assessment

A Level 2 functional assessment of the associated wetland areas was undertaken ((Kotze *et al*, 2007). This methodology provides for a scoring system to establish the services of the wetland ecosystem. As a result, a relative comparison of the associated systems based on a logical framework which measures the likelihood that a wetland is capable of performing certain functions was made (WetCS, 2006). The onsite wetlands were grouped according to homogeneity and assessed utilizing 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 HGM units as a whole for this study.

6.3 Determining the Present Ecological Status (PES) and Ecological Importance and Sensitivity (EIS) of wetlands

A present ecological status and ecological importance and sensitivity analysis was conducted in order to establish a baseline integrity for the associated wetlands. For the purpose of this assessment, the scoring system applied in the procedure for the determination of Resource Directed Measures for wetland ecosystems (DWAF, 1999) was applied. The output scores from the indices are presented in the standard DWAF A - F ecological categories, and provide a score of the PES of the habitat integrity of the wetland system being examined. According to Kleynhans and Louw (2007) EcoClassification is the procedure to determine and categorise the ecological state of various biological and physical attributes compared to the reference state. The used categories were modified from Kleynhans (1996 and 1999). In order to ascribe the individual category scores used in the assessment, air photo analysis, an assessment of the key drivers as well as limited field sampling were used. The interpretation of scores for determining PES is presented in Table 1 and the categories used to determine the EIS is presented in Table 2.

Table 1: Interpretation of scores for determining present ecological status (Kleynhans, 1999)

Categories	Classes	Ecological Description
A	Natural	Modifications to the natural abiotic template and the characteristics of the biota are undetectable. The characteristics of the resource are completely determined by unmodified natural regimes. Even potential anthropogenic induced changes to the abiotic characteristics and anthropogenic risks to the well-being of biota are not measurable.
A/B, B, B/C	Good	Modifications to the natural abiotic template and the characteristics of the biota may vary from small to moderate. The characteristics of the resource are largely determined by natural regimes while anthropogenic influences tend to play a small to moderate role. There is a small risk that the resource base may be exceeded. Consequently, the risk to the well-being and survival of especially intolerant biota (depending on the nature of the disturbance) at a limited number of localities may be somewhat higher than expected under natural conditions. Temporally and spatially this may result in somewhat lowered abundances and frequency of occurrence of intolerant and moderately intolerant species. However, even in the short, medium and long term the resilience and adaptability of biota are not compromised. The impact of acute disturbances on the biota is effectively mitigated by the presence of sufficient refuge areas.
C, C/D, D	Fair	Modifications to the natural abiotic template and the characteristics of the biota may vary from moderate to large. The characteristics of the resource are partly determined by natural regimes but anthropogenic influences tend to play a major role. There is a moderate to large risk that the resource base may be exceeded. Consequently, the risk to the well-being and survival of especially intolerant biota (depending on the nature of the disturbance) at a significant number of localities may be higher than expected under natural conditions. Temporally and spatially this may result in low abundances and frequency of occurrence of intolerant and moderately intolerant species, as well as a possible increase in the abundances and frequency of occurrence of tolerant species which may reach pest proportions. However, in the medium to long term the resilience and adaptability of biota are not compromised. The impact of local and acute disturbances are to an extent mitigated by some refuge areas.
E,F	Poor	Modifications to the natural abiotic template and the characteristics of the biota may vary from large to completely dominant. The characteristics of the resource are almost completely determined by severe anthropogenic influences. There is a serious to critical risk that the resource base may be exceeded. Consequently, the risk to the well-being and survival of all but the most tolerant biota (depending on the nature of the disturbance) at almost all localities is serious to critical. Temporally and spatially this will result in the absence of intolerant and moderately intolerant species and very low abundances and frequency of occurrence of moderately tolerant species. Tolerant species tend to increase in abundance and frequency of occurrence and can reach pest proportions. On all temporal and spatial scales the resilience and adaptability of biota are compromised. The impact of local and acute disturbances are to an extent mitigated by some refuge areas.

Table 2: Ecological importance and sensitivity categories. Interpretation of median scores for biotic and habitat determinants (Kleynhans, 1999).

Class	Description	Score
A	Floodplains that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 AND <=4
B	Floodplains that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 AND <=3
C	Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 AND <=2
D	Floodplains that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. The play an insignificant role in moderating the quantity and quality of water of major rivers.	0 AND <=1

7 KNOWLEDGE GAPS

This study did not include a full baseline assessment of the wetlands in the study area but used information generated from other specialist reports to supplement this report. Plant indicator species were used during the study to assist with the delineation.

An ecological assessment of the streams and dams on site was not conducted. Dams are regarded as artificial systems and do not provide an indication of the ecological integrity of the system. Additionally, the River Health Programme (RHP) methodologies described to assess a river/stream were developed for lotic systems (rivers and streams) and are not applicable to lentic ecosystems (dams, lakes, pans etc.). The lentic nature of the study area, combined with low flows and the dams, resulted in no RHP methodologies being implemented.

8 FINDINGS

8.1 General wetland description

The wetlands in the study area are linked to both perched groundwater and surface water. Five Hydro-geomorphic (HGM) types of natural wetland systems occur within the area assessed. These are:

- Valley bottom wetlands without channels.

- Hillslope seepage wetlands connected to watercourses;
- Hillslope seepage wetlands connected to pans;
- Isolated hillslope seepage wetlands; and
- Pans;

The various HGM types of wetland occurring in the study area is presented in Appendix B. The area (ha) and percentage of the different wetland types in relation to the study area and a description based on their setting in the landscape and hydrologic components are given in Tables 3 and 4 respectively.

Table 3: Area of the different HGM wetland types within the study area.

	Area of wetland assessed within study area	
Wetland type	**Hectares (ha)**	**Percentage (%)**
Valley bottom without channels	41.5	25.9
Hillslope seepage wetlands connected to watercourses	65.7	41.0
Hillslope seepage wetlands connected to pans	2.9	1.8
Isolated hisllslope seepage wetlands	48.8	30.4
Pans	1.4	0.9
Total	160.3	100.0

Dams occupy 5.44 ha of the study area and cover approximately 4% of the study area. Dams form the main artificial wetland type within the study area. The hillslope seepage wetlands connected to a watercourse occupy the greatest area, 65.7 ha and cover approximately 41% of total study area. The valley bottom wetlands without a channel and isolated hillslope seepage wetlands occupy similar size areas, namely 41.5 ha and 48.8 ha respectively. Each of these wetland types covers approximately 30% of the study area. A single pan is present within the study area and occupies 1.4 ha and the associated hillslope seepage wetland connected to the pan occupies an area of 2.9 ha. Approximately 30% of the study area is occupied by wetlands.

Table 4: The definition of the different HGM wetland types occurring in the study area [based on the system first described by Brinson (1993) and modified for the Highveld by Marneweck and Batchelor (2002), and further developed by Kotze *et al.*(2004)].

WETLAND TYPE	TOPOGRAPHIC SETTING	DESCRIPTION	HYDROLOGIC COMPONENTS		
			Inputs	**Throughputs**	**Outputs**
Valley bottom wetlands without channels	Occur in the shallow valleys that drain the slopes	Valley bottom areas without a stream channel. Are gently or steep sloped and characterized by the alluvial transport and deposition of material by water.	Receive water inputs from adjacent slopes via runoff and interflow. May also receive inputs from a channelled system. Interflow may be from adjacent slopes, adjacent hillslope seepage wetlands if these are present, or may occur longitudinally along the valley bottom.	Surface flow and interflow.	Variable but predominantly stream flow.
Hillslope seepage wetlands connected to watercourses	Hillslopes	Occur on concave or convex slopes immediately adjacent to, or at the head of watercourses including other wetlands. Characterized by the colluvial (transported by gravity) movement of materials. Generally always associated with sandy soil forms.	Predominantly groundwater from perched aquifers and interflow.	Interflow and diffuse surface flow.	Variable including interflow, diffuse surface flow and stream flow.
Hillslope seepage wetlands connected to pans	Along the slopes of pan basins	Occur adjacent to pans on the concave or convex slopes associated with the pan basin and are characterized by the colluvial (transported by gravity) movement of materials. Generally always associated with sandy soil forms.	Predominantly groundwater from perched aquifers and interflow.	Interflow and diffuse surface flow.	Variable but predominantly restricted to interflow and diffuse surface flow
Isolated hillslope seepage wetlands	Hillslopes	Occur as surface hydrologically isolated seepages with an unconfined seep front on concave or convex slopes which are characterized by the colluvial (transported by gravity) movement of materials. Generally always associated with sandy soil forms.	Predominantly groundwater from perched aquifers and interflow.	Interflow and diffuse surface flow.	Variable but predominantly restricted to interflow and diffuse surface flow .
Pans	In depressions and basins, often at drainage divides on top of the hills	A basin shaped area with a closed elevation contour that allows for the non-permanent (seasonal or temporary) accumulation of surface water. An outlet is usually absent.	Runoff from the surrounding catchment area and lateral seepage from adjacent hillslope seepage wetlands.	None.	Evapo-transpiration and groundwater discharge from leakage.

8.2 Description of wetland types

8.2.1 Valley bottom wetlands without channels

This type of wetland resembles a floodplain in it's location and gentle gradient, with potentially high levels of sediment deposition (Kotze *et al.,* 2007). Extensive areas of these wetlands remain saturated as stream channel input is spread diffusely across the wetland even at low flows (Kotze *et al.,* 2007). These wetlands also tend to have a high organic content. This is the dominant wetland type in the study area. 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).

8.2.2 Hillslope seepage wetlands

According to Kotze *et al. (*2007) these wetlands are usually associated with groundwater discharges, although flows through them may be supplemented by surface water contributors. These wetlands are expected to contribute to some surface flow attenuation early in the season until the soils are saturated, after which their contribution to flood attenuation will be limited (WRP, 1993; McCartney, 2000 and McCartney *et al.,* 1998). It is common for these soils to remain saturated for periods during the summer months (wet season). Two HGM types of hiilslope wetlands occur in the study area:

- Hillslope seepage wetlands connected to watercourses;
- Hillslope seepage wetlands connected to pans; and
- Isolated hillslope seepage wetlands

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. Hillslope seepage wetlands connected to pans are seepage systems situated on the slopes of pan basins which are connected to the pan and contribute to the hydrodynamics of the pan. Isolated hillslope seepage wetlands are isolated from other wetland systems and watercourses and in spite of this, this type of wetland system may be connected to other systems by subsurface flow (interflow). These systems are expressed as isolated seepage units in the landscape.

8.2.3 Pans

Pans receive water both from surface and groundwater flows, which then accumulates in the depression owing to a generally impervious underlying layer which prevents the water draining away (Goudie and Thomas, 1985; Marshall and Harmse, 1992). According to Kotze *et al.* (2007) pans are usually isolated from streams and because of there position in the landscape the opportunity for attenuating flows is limited. However, because of their inward draining nature they do capture runoff and as a result they reduce the volume of surface water that would otherwise reach the stream during stormflow conditions. According to Goudie and Thomas (1985) and Marshall and Harmse (1992) pans are not considered locations for the trapping of sediment, as many pans originate from the removal of sediment by wind, thus creating what are referred to as deflation basins.

8.3 Functional assessment of wetlands

Extensive literature searches have revealed that very few practitioners have quantified the benefits of wetland functionality. In addition to this, it appears likely that the functions of the wetlands are variable depending on the characteristics of the wetlands and landscape.

8.3.1 WET-EcoServices functional assessment

The general features of the wetlands were assessed in terms of functioning and the overall importance of each hydrogeomorphic unit was then determined at a landscape level. The level of functioning supplied by each of the hydrogeomorphic units for various ecological services is presented in Table 5. The results from the "WET-EcoServices" tool are presented below in Figures 1, 2, 3, 4 and 5.

Table 5: A listing and scoring of ecological services offered by each of the hydrogeomorphic units.

Summary Sheet	**Valley bottom wetland without a channel**	**Hillslope seepage wetland connected to a pan**	**Hillslope seepage wetland connected to a watercourse**	**Isolated hillslope seepage wetland**	**Pans**
	Overall Score	**Overall Score**	**Overall Score**	**Overall Score**	**Overall Score**
Flood attenuation	2.3	1.9	2.2	1.8	1.8
Streamflow regulation	3.2	2.2	2.4	1.4	2.0
Sediment trapping	2.5	1.9	3.1	2.5	1.9
Phospahte trapping	3.2	1.9	3.0	2.6	1.9
Nitrate removal	3.3	2.6	2.8	2.5	2.6
Toxicant removal	3.2	2.3	3.1	2.8	2.3
Erosion control	2.0	1.8	2.5	2.2	0.8
Carbon storage	2.0	1.7	2.3	2.0	1.3
Maintenance of biodiversity	2.3	2.4	1.7	1.6	2.7
Water supply for human use	2.7	1.4	1.2	0.9	2.0
Natural resources	1.2	0.8	0.8	0.8	1.0
Cultivated foods	0.2	0.8	0.8	0.8	0.2
Cultural significance	0.0	0.0	0.0	0.0	0.0
Tourism and recreation	1.3	0.6	0.7	0.9	1.1
Education and research	1.8	1.8	1.3	1.0	1.8

Note: The ecoservices supplied by the wetland systems are scored according to the following:

0 - Low

1 - Moderately Low

2 - Intermediate

3 - Moderately High

4 - High

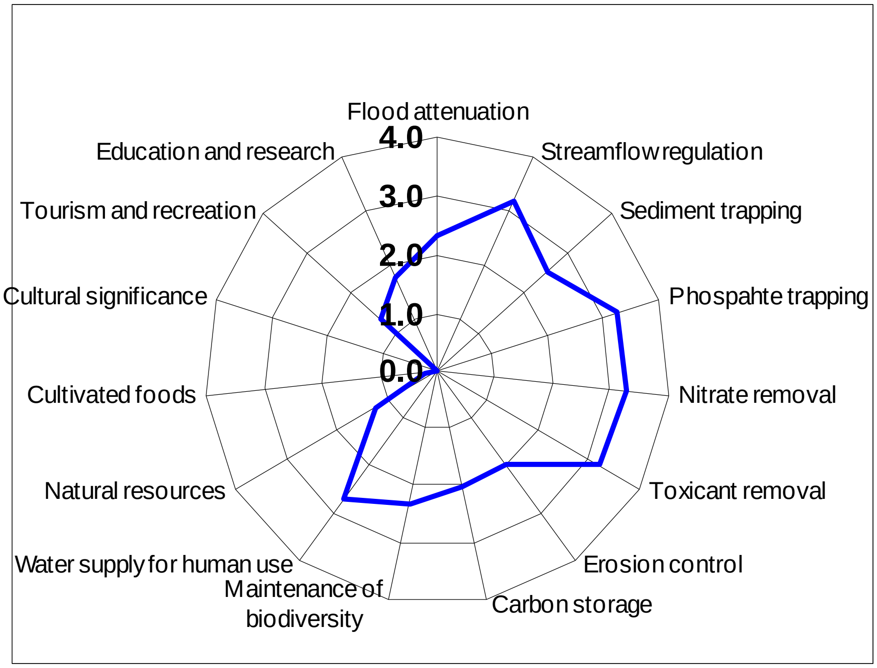


Figure 1: WET-EcoServices diagram for valley bottom wetlands without a channel

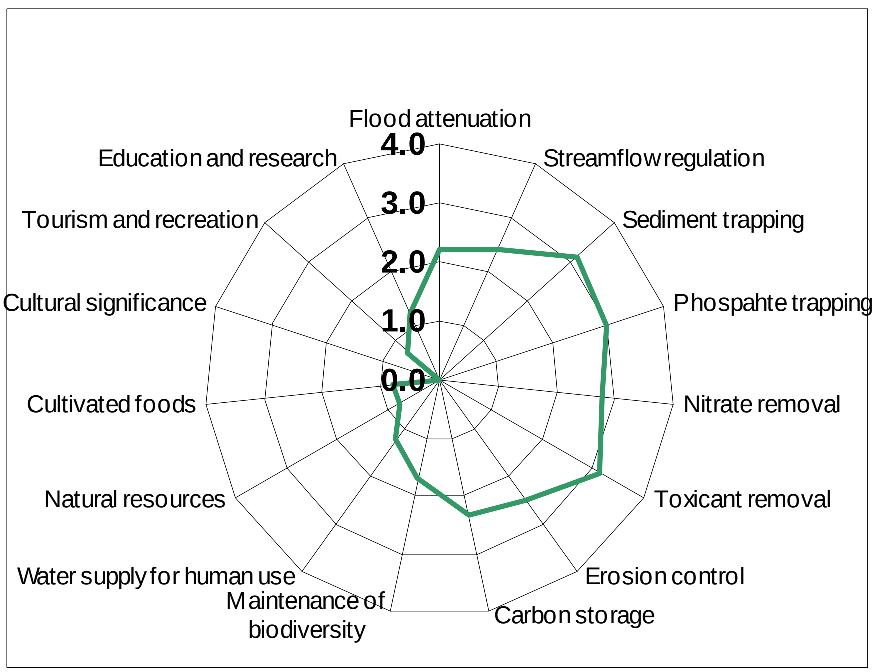


Figure 2: WET-EcoServices diagram for hillslope seepage wetlands connected to a watercourse

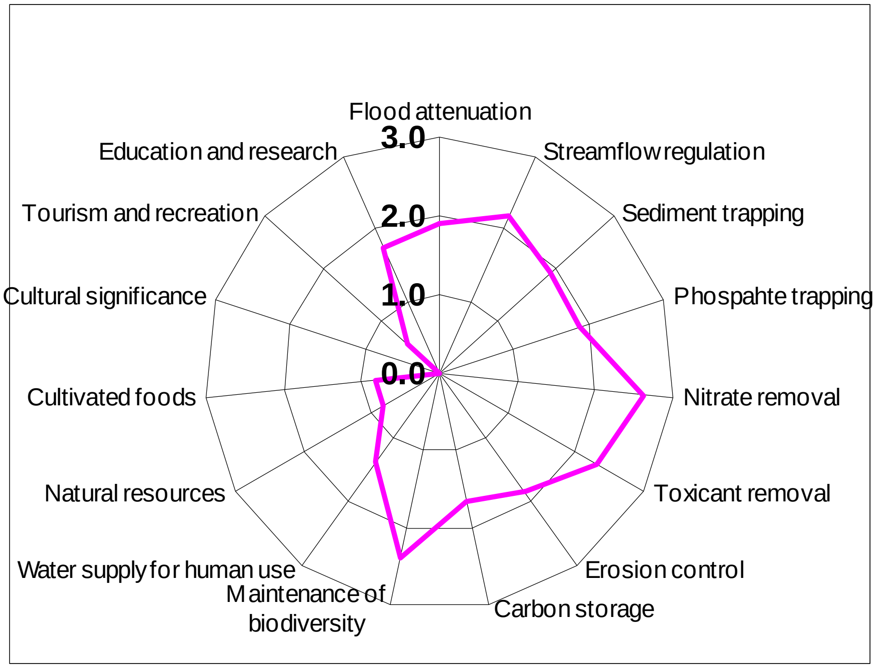


Figure 3: WET-EcoServices diagram for hillslope seepage wetlands connected to a pan

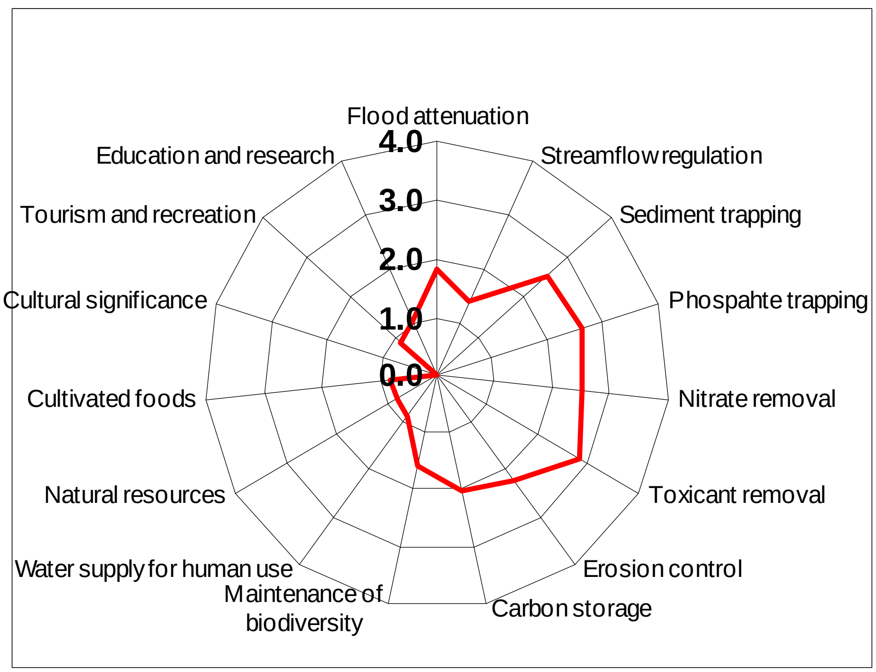


Figure 4: WET-EcoServices diagram for isolated hillslope seepage wetlands

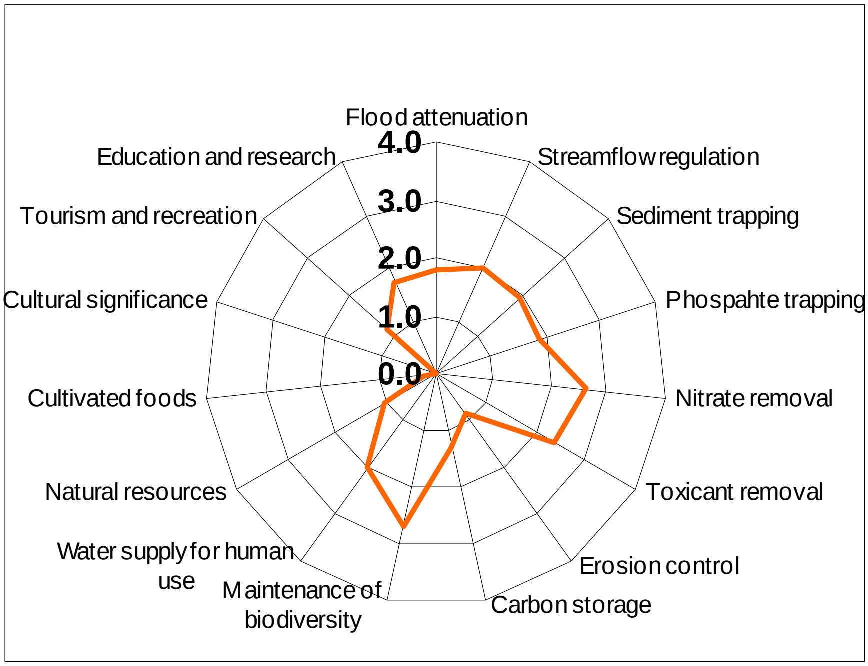
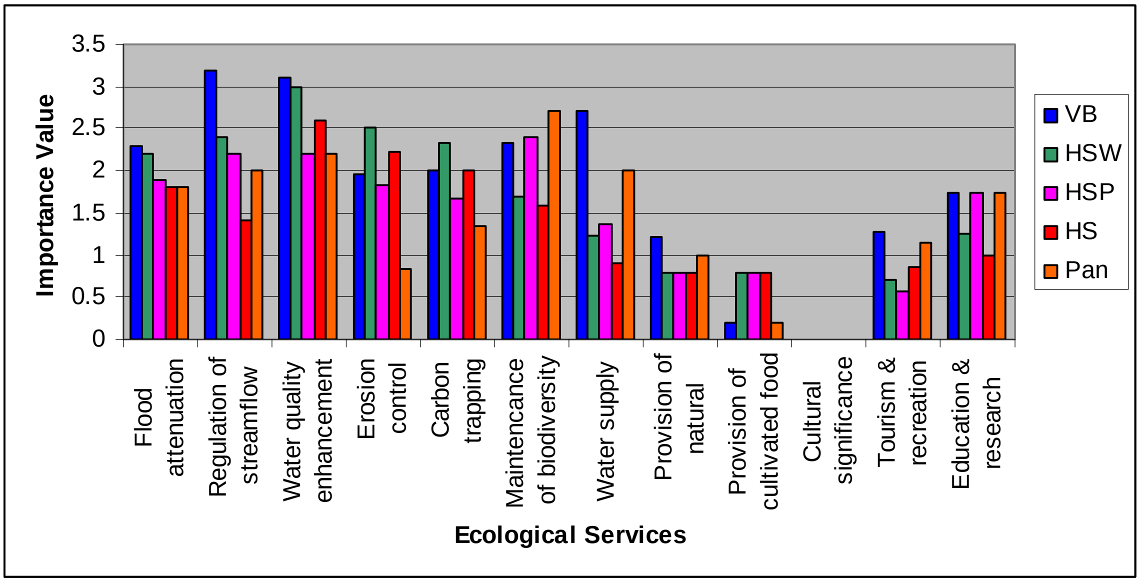


Figure 5: WET-EcoServices diagram for pans

From the above information it can be seen that the hillslope seepage wetlands connected to the watercourse, isolated hillslope seepage wetlands and the valley bottom wetlands score moderately high for ecoservices which would be considered to be providing benefits and services in terms of water quality enhancement. These three wetland units provide ecological services such as sediment trapping, phosphate trapping as well as nitrate and toxicant removal. The pan and associated hillslope seepage wetland obtained intermediate scores for similar water quality enhancement ecoservices provided. This is a clear indication that most important function of these wetland areas is the contribution of these wetland units to improve water quality within the catchment. The importance of the various ecological services offered for each wetland unit is presented in Figure 6. It is important to consider the proximity of agricultural land to the wetlands, the use of the wetlands by game and livestock as well as by humans. Additionally, the proposed mining activities may limit the quantity of water recharging the wetland areas as well as impact on the quality of available water, thus it may be assumed that the functioning of the wetland areas to offer services in terms of water quality improvement would become more important as mining operations progressed.



Note: VB – Valley bottom wetland

HSW – Hillslope seepage wetland connected to a watercourse

HSP – Hillslope seepage wetland connected to a pan

HS – Isolated hillslope seepage wetland

Pan – Pan

Figure 6: A summarised comparison of ecological services offer for each wetland unit and the importance of each service.

As a result of the reduction in the quantity of water recharging wetland areas, it may be assumed that certain wetland areas will be lost. However, in spite of this it is imperative that the loss of wetland areas is minimal so as to maintain the ecological services offered by the wetlands. The valley bottom wetlands receive water inputs from adjacent slopes via runoff and interflow from hillslope seepage areas. Hillslope seepage areas receive water inputs from groundwater, perched aquifers and interflow. A result of the proposed opencast mining activities there will be alterations in underground water dynamics as well as the removal of surface drainage areas. This in turn will limit the quantity of water reporting to the wetland areas downstream. Pans receive water inputs from runoff from the surrounding catchment area and lateral seepage from adjacent hillslope seepage wetlands and water is discharged from the pans into groundwater system via leakages. The proposed mining area will remove the pan and the associated catchment, hillslope seepage areas as well as surface areas contributing to sub-surface flow through. As a result of this impact, it is strongly recommended that where possible wetland areas downstream of the mining operation be recharged artificially. Wetlands share a primary driving force, water. Areas in the landscape where water accumulates for long enough and often enough to influence plants, animals and soils provide ecological functioning. A loss of water to these wetlands will mean a loss of ecological services provided for.

It was not possible to perform the types of investigations necessary for determining functionality (such as, for example, nutrient balance studies or flood attenuation quantifications) for this study. As a result it is extremely difficult to contemplate the specific functions performed by the wetlands identified for this study. In spite of these limitations, some general discussion is possible based on generalised functions that the types of wetlands detected in the area may perform.

8.3.2 Valley bottom wetlands without channels

Similarly to valley bottom wetlands with channels, valley bottom wetlands without channels also offer a service in the enhancement to the quality of water. This is with respect to the removal of toxicants and nitrates. This removal is higher than in valley bottom wetlands with channels owing to the greater contact of the wetland with runoff waters, particularly if there is a significant groundwater contribution to the wetland (Kotze *et al.,* 2007). According to Cronk and Siobhan Fennessy (2001) and Keddy (2002) the phosphate retention levels may be lower because a certain amount of phosphate may be re-mobilized under prolonged anaerobic conditions. These wetlands provide an additional service in trapping and the retention in the wetland itself of sediment carried by runoff waters. Finally, these wetland provide flood attenuation through the spreading out and the slowing down of floodwater in the wetland, thereby reducing the severity of floods downstream. Valley bottom wetlands without channels reduce the flooding potential as a result of diffuse flows over the surface of the wetland. This depositional environment is created by the surface roughness caused by the vegetation. The depositional environment is enhanced through the presence of dams. These wetlands provide valuable grazing ground during winter periods and early spring as a result of extended periods of wetness.

8.3.3 Hillslope seepage wetlands

According to Kotze *at al.* (2007) it is recognizable that evapotranspiration in the wetland may result in a considerable reduction in the volume of water which would otherwise potentially reach the stream system. The wetlands offer a service in that they accumulate organic matter and fine sediments in the wetland soils, this results in the wetland slowing down the sub-surface movement of water down the slope. This “plugging effect” thus increases the storage capacity of the slope above the wetland, and prolongs the contribution of water to the stream system during low flow periods (Kotze *et al.,* 2007). According to Rogers, Rogers and Buzer (1985), Gren (1995), Ewel (1997) and Postel and Carpenter (1997) these wetlands remove excess nutrients and inorganic pollutants produced by agriculture, industry and domestic waste. These wetland types have a relatively high removal potential for nitrogen in particular. There is an increase in erosion as the gradient of the slope increases and hillslope seepage wetlands tends not to be very important from an erosion control point of view, provided that the vegetation remains intact (Kotze *et al.,* 2007).

8.3.4 Pans

According to Kotze *et al.* (2007) the ability for attenuating floods is limited by the position of the pans in the landscape, which are generally isolated from stream channels. As a result of their inward draining nature, pans do catch runoff, and thus reduce the volume of water which would otherwise reach the stream system during stormflow conditions (Kotze *et al.,* 2007). According to Goudie and Thomas (1985) and Marshal and Harmse (1992) pans are not considered important locations for sediment trapping as many pans originate from the removal of sediment by wind, creating what is referred to as deflation basins.

Precipitation of minerals is carried out by temporary pans, including phosphate minerals due to the concentrating effects of evaporation (Kotze *et al.,* 2007). In addition to this, nitrogen cycling is likely to be important with some losses due to denitrification and volatilization in the case of high pH’s. According to Allan *et al.*(1995) the pedology, geology and local climate influence the water quality in pans. These factors in turn. Also influence the response of these systems to nutrient inputs (Kotze *et al.,* 2007). According to Kotze *et al.* (2007) accumulated salts and nutrients in non-perennial pans can be transported out of the system by wind and be deposited on the surrounding slopes. That which is remaining may then dissolve again when water enters the system as the pan fills after rainfall events.

8.4 The Present Ecological Status (PES) and Ecological Importance and Sensitivity (EIS) of wetlands

8.4.1 The Present Ecological Status

All of the wetlands within the study area have been modified to some extent with approximately 75% of the wetlands being moderately modified. Additionally, the remaining wetland areas have been largely modified. The classified PES areas for the study area are presented in Appendix C. The percentage relating to the PES is as follows:

- 76.3% are moderately modified (with a PES of C); and
- 23.7% are largely modified (with a PES of D).

The present state of the majority of the wetlands in the study area is therefore modified to some extent when compared with what would be expected for reference conditions. Areas which have been moderately modified are largely the result of agricultural practices, particularly damming, cultivation and livestock farming. All of these practices may impact on the quality of available water as well as increase the sediment loads reporting to the wetland areas. Moderately modified wetland areas have some loss of natural habitat. Wetland areas which have been largely modified are a result of the construction of roads, crossings, agricultural fields and drainage channels to drain wetland areas. These wetland areas have a large loss of natural habitat as well as a loss of basic ecosystem functioning.

8.4.2 Ecological Importance and Sensitivity

The relative ecological importance and sensitivity of the wetlands is shown in Appendix D. The highest ecological importance and sensitivity scores (rated as C – moderate) are associated with approximately 60% of the wetlands within the study area. These have the highest EIS scores predominantly as a result of their functioning to retain water and support adjacent wetland areas through interflow seepage. These wetland areas are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetland areas are not usually sensitive to flow and habitat modifications and in addition to this, these wetland areas play a small role in moderating the quantity and quality of water of major rivers.

Approximately 40% of all the wetlands within the study area have been rated low to marginal (rated as D) and these areas are no longer ecologically important and sensitive at any scale. The reason being, these areas are currently being disturbed and functioning altered through agricultural practices as well as with the destruction of wetland areas by road and drainage channel construction. As a result of this no biodiversity could be identified to be dependant on these systems. Additionally, these wetland areas will now play an insignificant role in moderating the quantity and quality of water of major rivers.

9 RECOMMENDATIONS

A soil, land capability and land use assessment was conducted by Rehab Green CC and findings from the survey have been used to supplement the findings from the wetland assessment. According to Rehab Green CC the delineated wetland areas play a very important part in the ecosystem which is already largely disturbed by agricultural activities. The wetland areas function as surface drainage systems, an important habitat and a mechanism to recharge the ground water system as well as open water sources downstream. In conclusion four of the seasonal and permanent wetland zones which form part of drainage lines and are linked to open water sources need to be protected and were excluded from the proposed opencast area. These wetland zones should also be protected by means of a 50m buffer zone.

Agricultural practices such as overgrazing and trampling, pasture conversions, damming and crop planting in wet areas are largely responsible for the current impacts on the biodiversity and water quality of the wetlands in the study area. While it is evident from the study that these impacts have affected the ecological state of the wetlands, in addition to this, impacts such as road and drainage channel construction and damming have seriously affected the underlying hydrology (key driver) supporting the wetland areas. The primary ecological service provided for by the wetland areas is the enhancement of water quality. The specific services offered for each wetland unit according to Kotze *et al.* (2007) are presented in Table 6. It is recommended that direct impacts to the wetland areas be restricted to the opencast area. Additionally, the functioning of the wetland areas should be artificially created so as to ensure the survival of the remaining wetland areas as well as their ability to offer ecological services in the way of water quality enhancement continues. Mitigation measures for the proposed mining activities are discussed below.

Table 6: Preliminary rating of the hydrological benefits likely to be provided by a wetland given its particular hydro-geomorphic type.

HGM	Regulatory benefits potentially provided by the wetland							
	Flood attenuation		Stream flow regulation	Erosion control	Enhancement of water quality			
	Early wet season	Late wet season			Sediment trapping	Phosphate trapping	Nitrate removal	Toxicant removal
Valley bottom unchannelled	+	+	+	++	++	+	+	++
Hillslope seepage wetland	+	#	+	++	#	#	++	++
Pan	+	+	#	#	#	#	+	+

Note: # Benefits unlikely to be provided to any significant extent

\+ Benefits likely to be present at least to some degree

++ Benefits very likely to be present (and often supplied to a high level)

9.1 Opencast mining

Given the extent and position of the proposed mining activities in proximity to the wetland areas, it may be assumed that these wetlands areas to the north and east of the study area will be impacted on with some wetland areas being lost completely. With regard to water quantity, the position of the wetland within the wetland system becomes an important consideration. Mining a wetland downstream from its origin will impact significantly on the water quantity reporting to the system, because the water flow form all upstream areas flowing into the wetland in question will no longer flow into the system due to the disturbance. The proposed mining area is at the origin of the wetland system and would therefore be a minor impact in terms of water quantity reporting to wetland systems further downstream as opposed to the mining area being downstream of the origin. There is little change in the natural drainage of the wetland system.

Water quality is another issue which needs to be considered. DWAF has guidelines for drinking and live-stock watering water qualities as well for aquatic ecosystems which should be incorporated into catchment management strategies. It is recommended that water quality guidelines be included, which will be water quality requirements to maintain sustainable ecological functioning in the river/wetland. Surface water quality will become a greater issue because of the proposed opencast mining. Issues such as storm water runoff carrying coal particles into natural streams, dust from opencast mines settling in wetlands and rivers, increased total dissolved solids, increased pH and increased electrical conductivity all impact on wetland functioning by disturbing natural sediments in wetlands and directly impacting and faunal and floral organisms critical to proper wetland functioning.

The proposed opencast area is adjacent to the hillslope seepage areas connected to the watercourse. It is recommended that a buffer zone be implemented for the valley bottom and hillslope seepage wetland areas so as to avoid a direct impact to these systems. The avoidance of the impact of the opencast area to the valley bottom wetland systems will allow for unrestricted flow of water in these units. A buffer zone of 60m is proposed for the valley bottom and associated hillslope seepage units.

In a post open cast mined landscape wetland rehabilitation is impractical due to the requirements to maintain a free draining area as well as maintain wetland function. In its own right, wetland rehabilitation is very difficult to achieve, thus the approach whereby an equivalent area to that being lost is rehabilitated elsewhere, seems most rational in terms of mitigation and/or rehabilitation at this stage. The opportunities for this type of approach in a nearby catchment should be explored based on clearly defined strategic objectives set for the sub-catchment. Organisations such as Working for Wetlands can assist in such decisions and developments. It is vital to extract plants and set up a nursery to house these plants when wetlands have been earmarked for opencast mining. All Red Data and endemic plants should be included and specialist wetland plants, particularly those of cultural value.

9.2 Haul road and mining infrastructure

The proposed haul road and mining infrastructure currently transects the hillslope seepage area to the south of the study area. The opencast mining operations will cause an interruption to both ground and surface water dynamics and so it may be assumed that this isolated hillslope seepage wetland to the south of the opencast mining area will be lost. In spite of hillslope seepage areas normally being associated with groundwater discharges, flow through may be supplemented by surface water contributions. In addition to this, these units contribute to some surface flow attenuation. As a result of this, any unnecessary destruction of the wetland area to the south of the mining activities should be avoided as these wetlands still provide ecological functions such as water quality enhancement. Recommendations for the placement of the proposed haul road and mining infrastructure are presented in Figure 7. These modifications will make use of an existing farm road as well as avoid the saturated areas and any unnecessary destruction and impacts to wetland areas downstream of the area.

Proposed placement of mine infrastructure | Proposed haul road

Recommended placement of mine infrastructure | Recommended haul road

Figure 7: The recommended haul road and mining infrastructure placement modifications to the south of the opencast area

9.3 Pollution control dam

The primary ecological function for the wetland areas associated with the study area is the enhancement of water quality such as the removal of excess nutrients and inorganic pollutants. The dominant HGM unit which will be destroyed is the hillslope seepage areas. These units offer ecoservices such as the removal of nitrogen. The functioning of the pollution control dams (PCDs) would be to capture and retain storm water runoff from the mined area and use this “dirty” water for the mining operations. The placement of PCD's for Pit 2 and 3 was determined to be good, however, it is recommended to change the placement of the PCD for Pit 1. The recommended placement area for the PCD for Pit 1 is presented in Figure 8. It is suggested that the PCDs be lined to minimize the impact of polluted water on the water resource as well as sediment managed to prevent silt build up. This will ensure that the holding capacity of the dams downstream is not reduced. This can be achieved with the inclusion of silt traps and an overflow into a lined pollution control dam. A polluted water diversion network (including drains, pipes, sumps, pumps etc) should be introduced to ensure all polluted water (wash water, spillages, process water etc) is captured and diverted to its intended destination (PCDs).

Proposed placement area for the PCD and trench associated with pit 1

Recommended placement area for the PCD and trench associated with pit 1

Figure 8: The proposed and suggested placement areas for the PCD and trench for Pit 1

The suggested placement of the two PCDs is within the catchment for each wetland area and located as far upstream of each wetland as possible. This will allow for a greater wetland area to provide ecological services such as water quality enhancement as water moves through the wetlands, improving the quality of water for downstream users.

Once the quality of treated water is within DWAF water quality guidelines, controlled discharge is suggested and must be monitored. Wetland areas downstream of the mining area are dependant on water as a resource to maintain their functioning, for this reason an artificial recharge strategy would need to be implemented. Discharge into the wetland areas needs to be controlled so as to mimic the natural flow regime as well as inputs of these wetland systems as closely as possible. Ecological services which would need to be maintained by wetland areas downstream of the opencast area are additional water quality enhancement and the prolonged contribution of water to the downstream system during low flow periods. It is important that the discharge from the PCD's does not physically alter the catchment area resulting in erosion and sedimentation of the wetland areas downstream.

9.4 Sedimentation

The wetland areas within the study area provide additional ecoservices such as erosion control, flood attenuation and sediment trapping. A result of the proposed mining activities would be de-vegetated areas and created earth piles. In order to minimize the impact of excessive sedimentation to the wetland areas it is recommended that earth piles be vegetated and gabions used in areas of high runoff potential to trap lose sediment. Additionally it is recommended to construct berms, approximately 1.0m – 1.5m high for the length of area between the opencast workings/soil stock piles and the wetland areas. The purpose of these berms would be to intercept flows containing suspended soils and create a depositional environment, inhibiting sediment introduction into the downslope wetland areas. It is also recommended that current agricultural fields on the periphery of the opencast area be rehabilitated to natural grasslands. This will minimize areas where lose sediment is available a result of the agricultural practices and in addition create areas which will contribute to erosion control and sediment trapping required for the mining activities.

9.5 Coal stockpile

The coal to be stored should be carefully managed to minimise dust emissions, water can be sprayed onto them, so that wind doesn't blow particles of coal onto adjacent systems and/or neighboring properties. An optional mitigation measures to prevent the remote possibility of groundwater contamination is with the installation of an impermeable liner under the stockpiles as a contingency against the possibility that coal from untested portions of the mine could contaminate water to a greater degree than the existing tests indicate. A detrimental effect of such a measure is the volume of contaminated surface runoff collected by the drainage systems. The use of impermeable liners is technically feasible but would represent substantial and possibly, unnecessary expense. The recommended stockpile area is presented in Figure 9. It is situated above an already disturbed area and this disturbed area can be rehabilitated to minimize runoff from the stockpile into the surrounding landscape. This can be achieved through vegetating the area and/or the use of gabions as well as berms.

Suggested ROM stockpile area Recommended ROM stockpile area

Figure 9: The proposed and suggested placement areas for the ROM stockpile

9.6 Diesel storage tank

It is recommended that diesel storage tanks are to be bunded or placed in sunken catchpits with bunded area adequately lined and covered with loose sand that is large enough to contain a significant spill, should it occur. Any possible spillage must be returned to the source via vertical pumps. In the unlikely event of any spillages outside bunded areas, as well as contaminated storm-water, flow to an emergency storage dam, for recycling back into the process. Furthermore, all bunded areas must be designed to contain a minimum of 150% of any tank volume inside its perimeter, in case of a failure of such a tank. Additionally, it is recommended that the placement of the tank be in the same area suggested for the mining infrastructure.

10 ENVIRONMENTAL IMPACT ASSESSMENT

10.1 EIA methodology

In order to clarify the purpose and limitations of the impact assessment methodology, it is necessary to address the issue of subjectivity in the assessment of the significance of environmental impacts. Even though DWA, and the majority of environmental impact assessment practitioners, propose a numerical methodology for impact assessment, one has to accept that the process of environmental significance determination is inherently subjective. The weight assigned to the each factor of a potential impact, and also the design of the rating process itself, is based on the values and perception of risk of members of the assessment team, as well as that of the interested and affected parties (IAPs) and authorities who provide input into the process. Whereas the determination of the spatial scale and the duration of impacts are to some extent amenable to scientific enquiry, the severity value assigned to impacts is highly dependent on the perceptions and values of all involved.

It has to be stressed that the purpose of the EIA process is not to provide an incontrovertible rating of the significance of various aspects, but rather to provide a structured, traceable and defendable methodology of rating the relative significance of impacts in a specific context. The methodology employed for environmental impact assessment is divided into two distinct phases, namely, impact identification and impact assessment.

10.1.1 Impact identification

Impact identification is performed by use of an Input-Output model which serves to guide the assessor in assessing all the potential instances of ecological and socio-economic change, pollution and resource consumption that may be associated with the activities required during the construction, operational, closure and post-closure phases of the project.

Outputs may generally be described as any changes to the biophysical and socio-economic environments, both positive and negative in nature, and also include the product and waste produced by the activity. Negative impacts could include gases, effluents, dust, noise, vibration, other pollution and changes to the bio-physical environment such as damage to habitats or reduction in surface water quantity. Positive impacts may include the removal of invasive vegetation, construction of infrastructure, skills transfer or benefits to the socio-economic environment. During the determination of outputs, the effect of outputs on the various components of the environment (e.g. topography, water quality, etc.) is considered.

10.1.2 Impact rating

The impact rating process is designed to provide a numerical rating of the various environmental impacts identified by use of the Input-Output model. As discussed above, it has to be stressed that the purpose of the EIA process is not to provide an incontrovertible rating of the significance of various aspects, but rather to provide a structured, traceable and defendable methodology of rating the relative significance of impacts in a specific context. This gives the project proponent a greater understanding of the impacts of his project and the issues which need to be addressed by mitigation and also give the regulators information on which to base their decisions.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability

Where

Consequence = Severity + Spatial Scale + Duration

And

Probability = Likelihood of an impact occurrin

The matrix first calculates the rating out of 75, and then converts this into a percentage out of 100. The percentage is the figure quoted in the matrix. The weight assigned to the various parameters for positive and negative impacts in the formula is presented in **Error! Reference source not found.** below.

Table 7: Impact assessment parameter ratings

Rating	Severity		Spatial scale	Duration	Probability
	Environmental	**Social, cultural and heritage**			
5	Very significant impact/total destruction of a highly valued species, habitat or ecosystem or extremely positive impact over baseline environmental condition.	Irreparable damage to/destruction of highly valued items of great cultural significance or complete breakdown of social order or Extremely positive impact on social, economic and cultural environment.	National/ International	Permanent/ Irreversible (more than 50 years)	Certain/ Normally happens in cases of this nature (80-100% chance of happening)
4	Serious impairment of ecosystem function. or very positive impact over baseline environmental condition	Serious social issues/Permanent damage to items of cultural significance or very positive impact on social, economic and cultural environment.	Provincial/ Regional	Long Term (25 to 49 years or beyond closure)	Will more than likely happen (60-79% chance)
3	Moderate negative alteration of ecosystem functioning or Moderately positive impact over baseline environmental condition	Moderately important social issues and/or moderately significant damage to items of cultural significance or Moderately positive impact on social, economic and cultural environment.	Regional (substantially beyond site boundary)	Medium Term (5-24 years)	Could happen and has happened here or elsewhere (40-59% chance)
2	Minor effects not affecting ecosystem functioning or Slightly positive impact over baseline environmental condition	Minor Impacts on the local population, repairable over time. Temporary impairment of the availability of items of cultural significance or Minor positive impact on social, economic and cultural environment	Local (beyond site boundary and affects neighbours)	Medium-Short Term (1-4 years)	Has not happened yet, but could (20-39% chance)
1	Insignificant effects on the biophysical environment or Insignificantly positive impact over baseline environmental condition	Insignificant social issues / low-level repairable damage to commonplace structures. positive impact on social, economic and cultural environment or Insignificant positive impact on social, economic and cultural environment	Site (does not extend beyond site boundary)	Short term (Less than a year)	Conceivable, but only in a set of very specific and extreme circumstances (0-19% chance)

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in the EMP. The significance of an impact is then determined and categorised into one of four categories, as indicated in **Error! Reference source not found.**. In accordance with Regulation 51 of the MPRDA, management actions will be assigned for all impacts, irrespective of significance. The environmental impact assessment for each relevant activity is presented in Table 9. Additionally, the suggested management for each identified impact is presented in Table 10.

Table 8: Significance threshold limits

Category	Description	Colour
High	76 %- 100%	
Medium – High	51% – 75%	
Medium - Low	26% – 50%	
Low	0% - 25%	

11 ENVIRONMENTAL IMPACT ASSESSMENT

Table 9: The listed activities described for each phase and the impact description and significance rating thereof

Activity	Phase	Affected environment	Impact	Status	Severity	Reversibility	Spatial Scale	Duration	Probability	Significance rating
Removal of topsoil	Construction	Sensitive landscape	Topsoil and overburden stripping and vegetation removal reduces recharge of shallow aquifers that feed hillslope wetlands, reducing flow in water resources	N	4	3	3	3	4	53
Stockpiling of soil and overburden from initial cuts	Construction	Sensitive landscape	Sedimentation of the water resources due to erosion of the stockpiles during periods of high rainfall.	N	3	3	3	3	3	36
Construction of hydrocarbons storage facilities	Construction	Sensitive landscape	Potential pollution of surface water resources due to hydrocarbon spillage and leaks may impact negatively on wetland functioning	N	3	3	3	3	3	36
Construction of storm water diversion berms	Construction	Sensitive landscape	Loss of water due to the channelling of water away from seepage areas and water resources	N	3	3	3	3	5	60
Development of initial open cast cuts	Construction	Sensitive landscape	Establishment of opencast areas dewaters surrounding aquifers	N	5	4	3	5	5	87
Construction of offices and change houses	Construction	Sensitive landscape	Reduction on surface water quantity due to reduction in catchment size reduces the amount of surface water reporting to wetland areas, reducing their size and function. Hardening of surfaces will limit seepage areas.	N	3	3	3	3	5	60
Construction of a workshop	Construction	Sensitive landscape	Reduction on surface water quantity due to reduction in catchment size reduces the amount of surface water reporting to wetland areas, reducing their size and function. Hardening of surfaces will limit seepage areas.	N	3	3	3	3	5	60
Construction of haul roads	Construction	Sensitive landscape	Reduction on surface water quantity due to reduction in catchment size reduces the amount of surface water reporting to wetland areas, reducing their size and function. Hardening of surfaces will limit seepage areas.	N	3	3	3	3	5	60
Construction of pollution control dams	Construction	Sensitive landscape	Reduction in surface and ground water due to dirty water in the pollution control dams as well as potential pollution of surface water resources due the incorrect handling of dirty water may impact negatively on wetland functioning and water quality.	N	5	3	3	3	3	44
Mining process removal of coal	Operational	Sensitive landscape	Topsoil and overburden stripping and vegetation removal reduces recharge of shallow aquifers that feed hillslope wetlands, reducing flow in water resources. Establishment of opencast areas dewaters surrounding aquifers	N	4	4	3	3	4	53
Removal of overburden and backfilling	Operational	Sensitive landscape	Sedimentation of the water resources due to erosion of the overburden during periods of high rainfall. Topsoil and overburden stripping and vegetation removal reduces recharge of shallow aquifers that feed hillslope wetlands, reducing flow in water resources	N	4	3	3	3	4	53
Operation of fuel depot	Operational	Sensitive landscape	Potential pollution of surface water resources due to hydrocarbon spillage and leaks may impact negatively the water resources.	N	3	3	3	3	3	36
Operation of portable ablutions	Operational	Sensitive landscape	Potential pollution of surface water resources due to the incorrect handling of	N	3	3	3	3	3	36

			domestic wastes and sewerage may impact negatively the water resources.							
Domestic and industrial waste storage and removal	Operational	Sensitive landscape	Potential pollution of surface water resources due to pollutant and toxicant spillage and leaks may impact negatively the water resources.	N	3	3	3	3	3	36
Operation of pollution control dam and storm water management systems	Operational	Sensitive landscape	Potential pollution of surface water resources due to dirty water spillage and leaks may impact negatively the water resources, impacting on ecological functioning and water quality.	N	5	3	3	3	3	44
Hazardous waste storage and removal	Operational	Sensitive landscape	Potential pollution of surface water resources due to the incorrect handling of hazardous, industrial and domestic wastes and sewerage may impact negatively the water resources.	N	3	3	3	3	3	36
ROM coal Stockpile	Operational	Sensitive landscape	Potential pollution of surface water resources due to the runoff from the stockpiles may impact negatively on the water resources.	N	3	3	3	3	3	36
Rehabilitation as mining progresses	Operational	Sensitive landscape	Reduction in catchment size may be limited and seepage areas restored to maintain sub-surface flow dynamics and restore ecological functioning	N	2	2	3	3	3	32
Maintenance of equipment	Operational	Sensitive landscape	Potential pollution of surface water resources due to pollutant and toxicant spillage and leaks may impact negatively the water resources.	N	3	3	3	3	3	36
Re-vegetation of disturbed areas	Decommission	Sensitive landscape	The erosion potential of vegetated areas is reduced as well as runoff potential reduced. This will allow for infiltration of the vegetated areas, contribution to sub-surface flow dynamics.	P	4	3	3	3	4	53
Environmental monitoring of decommissioning activities	Decommission	Sensitive landscape	An aquatic biomonitoring programme will monitor potential impacts to the immediate aquatic surface ecosystem and where needed, corrective action taken and rehabilitation measures implemented.	N	3	3	3	3	4	48
Filling of final void	Decommission	Sensitive landscape	Restoration and rehabilitation of sub-surface and surface flow dynamics. This is only achieved if soils are separately correctly and managed and the original soil profile is restored.	P	4	4	3	3	4	53
Spreading of sub-soils and topsoil	Decommission	Sensitive landscape	Restoration and rehabilitation of sub-surface and surface flow dynamics. This is only achieved if soils are separately correctly and managed and the original soil profile is restored.	P	4	3	3	3	4	53
Profiling and contouring of the area to preserve natural drainage lines	Decommission	Sensitive landscape	Restoration and rehabilitation of drainage lines, seepage areas to restore the original surface flow dynamics.	P	4	3	3	3	4	53
Removal of all infrastructure	Decommission	Sensitive landscape	Potential pollution of surface water resources due to the removal of management facilities from spills and leaks may impact negatively on the water resources.	N	3	3	3	3	3	36

12 MANAGEMENT OF IDENTIFIED ENVIRONMENTAL IMPACTS

Table 10: The described management plans for the listed activities per phase and the significance rating thereof

Activity	Phase	Affected environment	Impact	Mitigation	Responsible person	Frequency/ Duration	Significance rating		Financial Plan	
							Before mitigation	After mitigation	Concurrent	Final
Removal of topsoil	Construction	Sensitive landscapes	Topsoil and overburden stripping and vegetation removal reduces recharge of shallow aquifers that feed hillslope wetlands, reducing flow in water resources	Removal of vegetation during stripping and dump construction will be minimised to reduce the erosion potential. Topsoil will only be removed off areas proposed for immediate mining.	Environmental co-ordinator	3	Medium/high	Medium/low		
Stockpiling of soil and overburden from initial cuts	Construction	Sensitive landscapes	Sedimentation of the water resources due to erosion of the stockpiles during periods of high rainfall.	Soil and overburden stockpiles will be vegetated to prevent erosion as well as berms constructed downslope of the piles to trap debris. The berms will also allow for infiltration of water.	Environmental co-ordinator	3	Medium/low	Medium/low		
Construction of hydrocarbons storage facilities	Construction	Sensitive landscapes	Potential pollution of surface water resources due to hydrocarbon spillage and leaks may impact negatively on wetland functioning	A hydrocarbon management system will be introduced on site to ensure that potential pollution of the water resource will be minimised	Environmental co-ordinator	3	Medium/low	Medium/low		
Construction of storm water diversion berms	Construction	Sensitive landscapes	Loss of water due to the channelling of water away from seepage areas and water resources	Berms will be constructed to collect clean water and divert it around the mine workings with the intention of directing the water into the nautral drainage system downstream of the workings. Channels will be constructed to limit impacts to the quality of water being diverted.	Environmental co-ordinator	3	Medium/high	Medium/low		
Development of initial open cast cuts	Construction	Sensitive landscapes	Establishment of opencast areas dewaters surrounding aquifers	All construction activities will be planned and managed to ensure that there will not be a dramatic reduction in catchment size and water reporting to the wetland. Opencast establishment will dewater the surrounding aquifers and the impacts will be unavoidable, because of this mitigation will not be possible.	Environmental co-ordinator	3	high	high		
Construction of offices and change houses	Construction	Sensitive landscapes	Reduction on surface water quantity due to reduction in catchment size reduces the amount of surface water reporting to wetland areas, reducing their size and function. Hardening of surfaces will limit seepage areas.	All construction activities will be planned and managed to ensure that there will not be a dramatic reduction in catchment size and water reporting to the wetland. Permeable materials to be used ie permeable pavements, gardens can be constructed to be below pavement levels and a stormwater runoff programme implemented.	Environmental co-ordinator	3	Medium/high	Medium/low		
Construction of a workshop	Construction	Sensitive landscapes	Reduction on surface water quantity due to reduction in catchment size reduces the amount of surface water reporting to wetland areas, reducing their size and function. Hardening of surfaces will limit seepage areas.	All construction activities will be planned and managed to ensure that there will not be a dramatic reduction in catchment size. Permeable materials to be used ie permeable pavements and a stormwater runoff programme implemented.	Environmental co-ordinator	3	Medium/high	Medium/low		
Construction of haul roads	Construction	Sensitive landscapes	Reduction on surface water quantity due to reduction in catchment size reduces the amount of surface water reporting to wetland areas, reducing their size and function. Hardening of surfaces will limit seepage areas.	All construction activities will be planned and managed to ensure that there will not be a dramatic reduction in catchment size. Efforts will be made to limit the construction of haul roads in wetland areas. Haul raods will be low in gradient to limit reduce runoff velocity.	Environmental co-ordinator	3	Medium/high	Medium/low		

Activity	Phase	Affected environment	Impact	Mitigation	Responsible person	Frequency/ Duration	Significance rating: Before mitigation	Significance rating: After mitigation	Financial Plan: Concurrent	Financial Plan: Final
Construction of pollution control dams	Construction	Sensitive landscapes	Reduction in surface and ground water due to dirty water in the pollution control dams as well as potential pollution of surface water resources due the incorrect handling of dirty water may impact negatively on wetland functioning and water quality.	A waste water management system will be introduced on site to ensure that potential pollution of the water resource will be minimised	Environmental co-ordinator	3	Medium/low	Medium/low		
Construction of portable crusher plant	Construction	Sensitive landscapes	Reduction on surface water quantity due to reduction in catchment size reduces the amount of surface water reporting to wetland areas, reducing their size and function. Hardening of surfaces will limit seepage areas.	All construction activities will be planned and managed to ensure that there will not be a dramatic reduction in catchment size. Permeable materials to be used ie permeable pavements and a stormwater runoff programme implemented.	Environmental co-ordinator	3	Medium/high	Medium/low		
Mining process removal of coal	Operational	Sensitive landscapes	Topsoil and overburden stripping and vegetation removal reduces recharge of shallow aquifers that feed hillslope wetlands, reducing flow in water resources. Establishment of opencast areas dewaters surrounding aquifers	All construction activities will be planned and managed to ensure that there will not be a dramatic reduction in catchment size. Opencast establishment will dewater the surrounding aquifers and the impacts will be unavoidable, because of this mitigation will not be possible.	Environmental co-ordinator	3	High	High		
Removal of overburden and backfilling	Operational	Sensitive landscapes	Sedimentation of the water resources due to erosion of the overburden during periods of high rainfall. Topsoil and overburden stripping and vegetation removal reduces recharge of shallow aquifers that feed hillslope wetlands, reducing flow in water resources	Removal of vegetation during stripping will be minimised to reduce the erosion potential. Topsoil will only be removed off areas proposed for immediate mining.	Environmental co-ordinator	3	Medium/high	Medium/low		
Operation of fuel depot	Operational	Sensitive landscapes	Potential pollution of surface water resources due to hydrocarbon spillage and leaks may impact negatively the water resources.	A hydrocarbon management system will be introduced on site to ensure that potential pollution of the water resource will be minimised	Environmental co-ordinator	3	Medium/low	Medium/low		
Operation of portable ablutions	Operational	Sensitive landscapes	Potential pollution of surface water resources due to the incorrect handling of domestic wastes and sewerage may impact negatively the water resources.	Waste management will be ongoing throughout the life of the mine. This will ensure that the potential pollution of the water resources due to the incorrect handling of sewerage will be minimised	Environmental co-ordinator	3	Medium/low	Medium/low		
Domestic and industrial waste storage and removal	Operational	Sensitive landscapes	Potential pollution of surface water resources due to pollutant and toxicant spillage and leaks may impact negatively the water resources.	Waste management will be ongoing throughout the life of the mine. This will ensure that the potential pollution of the water resources due to the incorrect handling of industrial and domestic wastes and sewerage will be minimised	Environmental co-ordinator	3	Medium/low	Medium/low		
Operation of pollution control dam and storm water management systems	Operational	Sensitive landscapes	Potential pollution of surface water resources due to dirty water spillage and leaks may impact negatively the water resources, impacting on ecological functioning and water quality.	Water management will be ongoing throughout the life of the mine. This will ensure that the potential pollution of the water resources due to the incorrect handling of dirty water and wastes will be minimised	Environmental co-ordinator	3	Medium/low	Medium/low		
Hazardous waste storage and removal	Operational	Sensitive landscapes	Potential pollution of surface water resources due to the incorrect handling of	Waste management will be ongoing throughout the life of the mine. This will ensure that the potential pollution of the water	Environmental co-ordinator	3	Medium/low	Medium/low		

			hazardous, industrial and domestic wastes and sewerage may impact negatively the water resources.	resources due to the incorrect handling of hazardous wastes will be minimised						
ROM coal Stockpile	Operational	Sensitive landscapes	Potential pollution of surface water resources due to the runoff from the stockpiles may impact negatively on the water resources.	Berms created below the piles to trap coal particles and runoff from the coal stockpile	Environmental co-ordinator	3	Medium/low	Medium/low		
Rehabilitation as mining progresses	Operational	Sensitive landscapes	Reduction in catchment size may be limited and seepage areas restored to maintain sub-surface flow dynamics and restore ecological functioning	Increase in catchment area and restoration of wetland soil profiles which will restore surface and sub-surface flow dynamics. Thus restoring ecological services	Environmental co-ordinator	3	Medium/low	Medium/low		
Maintenance of equipment	Operational	Sensitive landscapes	Potential pollution of surface water resources due to pollutant and toxicant spillage and leaks may impact negatively the water resources.	An equipment management system will be introduced and operated for the life of mine. This will ensure the proper maintenance of all equipment to prevent the potential pollution of the water resource	Environmental co-ordinator	3	Medium/low	Medium/low		
Activity	**Phase**	**Affected environment**	**Impact**	**Mitigation**	**Responsible person**	**Frequency/ Duration**	**Significance rating**		**Financial Plan**	
							Before mitigation	**After mitigation**	**Concurrent**	**Final**
Re-vegetation of disturbed areas	Decommission	Sensitive landscapes	Surface water velocity is reduced which will allow the water to infiltrate into the soil profile and the wetland soil will enhance the quality of available water for the system.	The erosion potential of vegetated areas is reduced as well as runoff potential reduced. This will allow for infiltration of the vegetated areas, contribution to sub-surface flow dynamics.	Environmental co-ordinator	3	Medium/high	Medium/high		
Environmental monitoring of decommissioning activities	Decommission	Sensitive landscapes	This will allow for the determination of spatial and temporal trends regarding the integrity of the system. This will identify any long term impact to the system. The biomonitoring programme should be initiated before mining commences.	An aquatic biomonitoring programme will monitor potential impacts to the immediate aquatic surface ecosystem and where needed, corrective action taken and rehabilitation measures implemented.	Environmental co-ordinator	3	Medium/low	Medium/high		
Filling of final void	Decommission	Sensitive landscapes	The soil profile will be rehabilitated to allow for restoration of sub-surface flow dynamics. Soils not to be compacted which will prevent sub-surface flow	Restoration and rehabilitation of sub-surface and surface flow dynamics. This is only achieved if soils are separately correctly and managed and the original soil profile is restored.	Environmental co-ordinator	3	Medium/high	Medium/high		
Spreading of sub-soils and topsoil	Decommission	Sensitive landscapes	The soil profile will be maintained to allow for restoration of sub-surface and surface flow dynamics. Soils not to be compacted which will prevent sub-surface flow	Restoration and rehabilitation of sub-surface and surface flow dynamics. This is only achieved if soils are separately correctly and managed and the original soil profile is restored.	Environmental co-ordinator	3	Medium/high	Medium/high		
Profiling and contouring of the area to preserve natural drainage lines	Decommission	Sensitive landscapes	Contours will be created to match the original contour profiles for the area. This will attempt to recreate surface flow dynamics and seepage areas for wetlands	Restoration and rehabilitation of drainage lines, seepage areas to restore the original surface flow dynamics.	Environmental co-ordinator	3	Medium/high	Medium/high		
Removal of all infrastructure	Decommission	Sensitive landscapes	Decommissioning to take place during the dry season or during periods of low rainfall. Vehicles to make use of existing roads. All mining vehicles to be maintained to prevent spillages and leaks into the water resources. Vehicles impacting on areas	Potential pollution of surface water resources due to the removal of management facilities from spills and leaks may impact negatively on the water resources.	Environmental co-ordinator	3	Medium/low	Medium/low		

			previously unimpacted.							

13 ENVIRONMENTAL MONITORING PROGRAMMES

In order to directly measure, assess and report on the current health status and long term trends of the state of the aquatic ecosystem associated with the activities assessed in the study area, the establishment of an aquatic monitoring programme is recommended. An additional purpose of a monitoring program can be to facilitate activities by obtaining and monitoring compliance of for water user licenses. These licenses relate to the legal requirement of water users to adhere to Source Directed Control (SDC) measures which are related to established Resource Quality Objectives according the aquatic reserve for catchments (National Water Act (Act 36, 1998)).

To ensure that the futures Resource Quality Objectives, to be designated for the catchment, are attained, it is recommended that a responsibility-driven approach towards the management of the aquatic ecosystem associated with the study area be followed. The purpose for such a monitoring strategy will be to examine the long-term environmental trends of the aquatic resources associated with the mining activities in a practical and achievable manner.

The proposed indices for the monitoring strategy include IHI, IHAS, SASS5, FAII, RVI and basic *in situ* water chemistry. In addition to this, toxicant screening should also be implemented and where toxicants are identified definitive analysis carried out. The frequency for such a monitoring programme should be implemented bi-annually during the construction and operation phase of the project, and then annually after closure of the mine until rehabilitation of the area is satisfactory. Thereafter, any non-compliance with the Resource Quality Objectives should be identified and mitigated accordingly.

In the unlikely event of any pollution event occurring it is strongly suggested that a Pollution Action Plan be implemented and the frequency of the monitoring strategy should be adjusted accordingly. This will help to identify the source of the event and mitigation can be formulated accordingly. It is strongly recommended that an assessment of the aquatic ecosystem be conducted as soon as possible after such an event. This will help to identify the magnitude and severity of such an event on the health of the aquatic ecosystem. A follow-up survey should be conducted approximately two months after the event in order to determine the effectiveness of the applied mitigation measures.

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Appendix A: A curriculum vitae (CV) and declaration of independence

ANDREW HUSTED

Mr Andrew Husted
Aquatic Ecologist
Digby Wells & Associates

EDUCATION

2006 - 2007:	BSc Masters in Aquatic Health – University of Johannesburg (UJ)
2005 – 2006:	BSc Hons. Zoology – Aquatic Health – Rand Afrikaans University (RAU)
2005 – 2003:	BSc Natural Science – Zoology & Botany (RAU)

EMPLOYMENT

January 2006 – June 2007: Econ@UJ, as an aquatic ecologist
August 2007 – present: Digby Wells and Associates, as an aquatic ecologist:

EXPERIENCE

Before joining DWA I was employed by Econ@UJ, a consortium based at the University of Johannesburg specializing in aquatic ecology as a researcher and project manager. I was involved in a number of projects at all levels. Through this I gained a wealth of experience in terms of aquatic assessments, project management and co-ordination and report writing. I was also responsible for the management of other master degree studies, ensuring work was completed correctly and the deliverables were met as well as written articles were correct and accurate.

Special areas of interest include:

- **Aquatic ecosystem integrity, importance and sensitivity:**
  - Fish survey
    - Fish Assemblage Integrity Index (FAII) or if required the Fish Response Assessment Index (FRAI).
    - Fish Health Index (FHI)
    - Biodiversity report highlighting IUCN listed species.
  - Invertebrate survey
    - South African Scoring System Verison 5 index and if required the Macro Invertebrate Response Assessment Index (MIRAI).
    - Biodiversity report highlighting IUCN listed species.
  - Riparian and wetland vegetation survey

Application of the Vegetation Response Assessment Index (modification from RVI).

Rapid assessment of the ecological state of Wetland ecosystems.

Biodiversity report highlighting IUCN listed species.

- Habitat surveys
  - Index of Habitat Integrity (IHI)
  - Integrated Habitat Assessment System (IHAS)
  - Habitat Quality Index (HQI)
- Water quality assessment
  - Oxygen content and saturation, conductivity, pH and temperature (in situ).
  - General nutrient, salinity and toxic components of the samples.

- **Wetland Delineation:**
  - 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
  - Vegetation Indicator – identifies hydrophilic vegetation associated with frequently saturated soils

- **Estuarine Ecological State, Importance and Sensitivity Assessments:**
  - Estuarine Fish Condition Index

PAST PROJECTS

- Coal of Africa, Mpumulanga: GVM – Aquatic Assessment
- Exxaro, Mpumulanga: Arnot Conveyor – Wetland Delineation & Aquatic Biomonitoring
- Kevin Ridge, Gauteng: GDACE – Basic Assessment
- Randgold, Ivory Coast: Tongon – Aquatic Assessment, River Diversion
- Total Coal SA, Mpumulanga: Springbok Siding – Aquatic Biomonitoring
- Xstrata, Mpumulanga: Butterfly Pit – Aquatic Assessment, River Diversion
- Xtrata, Mpumulanga: Spitzkop - Wetland Delineation & Aquatic Assessment

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SPECIALIST DECLARATION OF INDEPENDENCE

I, Andrew Husted, declare that I –

- Act as the independent specialist for the undertaking of a specialist section for the proposed project Wetland Delineation, Northern Coal ;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2006;
- Do no have nor will have a vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2006;

Andrew Husted
Name of the specalist

Signature of the specalist

Digby Wells & Associates
Name of company

12 May 2009
Date

Appendix B: Distribution and extent of wetland types in the study area.

Plan 1

Northern Coal Weltevreden
Wetland Delineation

Legend

- Weltevreden Site
- 5m Contours

Wetland delineation

- Hillslope seepage connected to pan
- Hillslope seepage connected to water course
- Isolated hillslope seepage
- Pan
- Valley bottom without a channel
- Dams
- Minor Road
- Perennial Stream
- Non-Perennial Stream

Projection: Transverse Mercator
Central Meridian: Lo31
Datum: WGS84

1:12,000

0 75 150 300 450 600
Meters

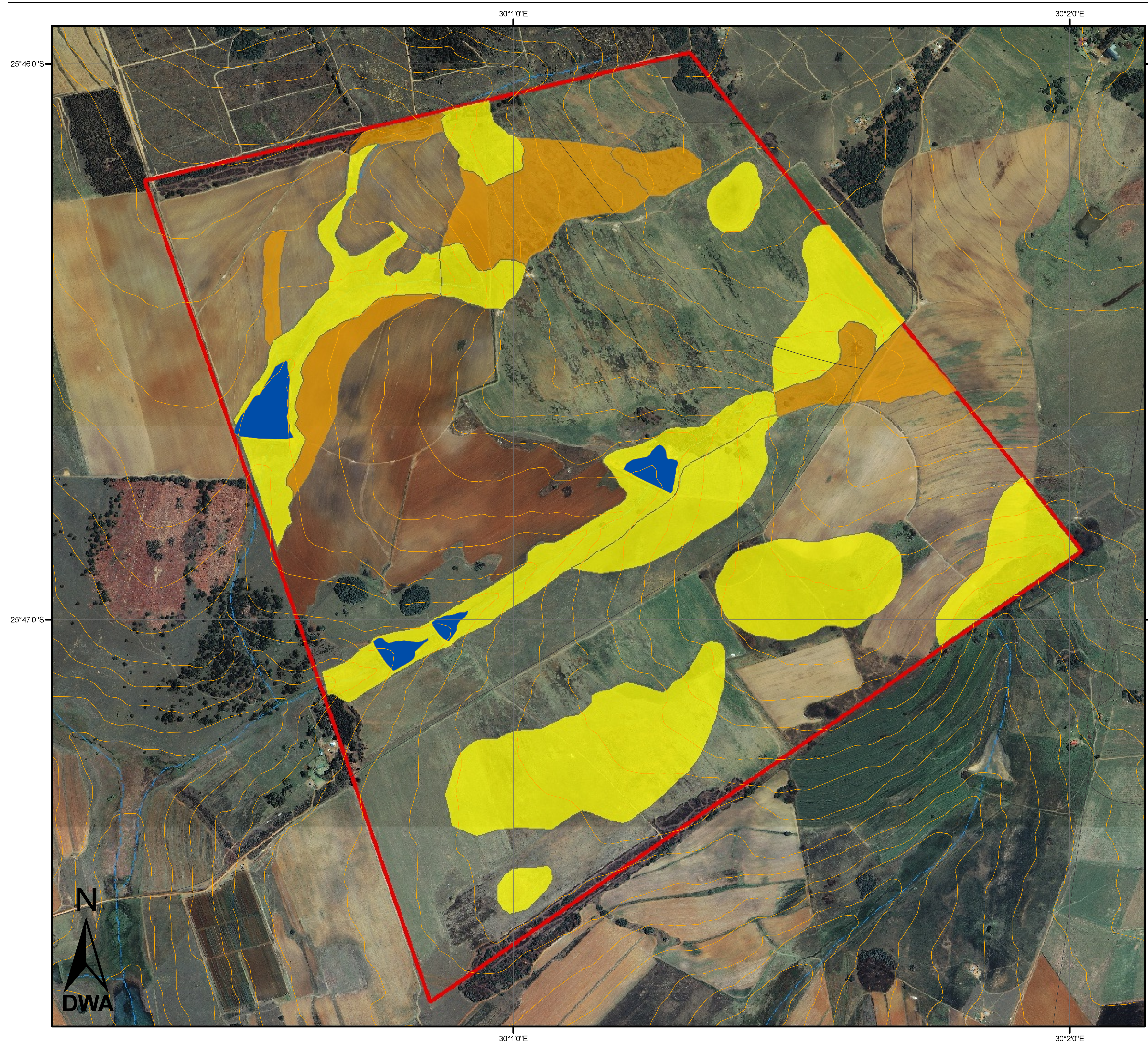
Ref:/bjt.NOR335.200806.001

Appendix C: The Present Ecological State (PES) of wetlands associated with the study area

Plan 2

Northern Coal Weltevreden

Present Ecological State



Legend

Weltevreden Site

5m Contours

Wetland delineation

PES C

PES D

Dams

Minor Road

Perennial Stream

Non-Perennial Stream

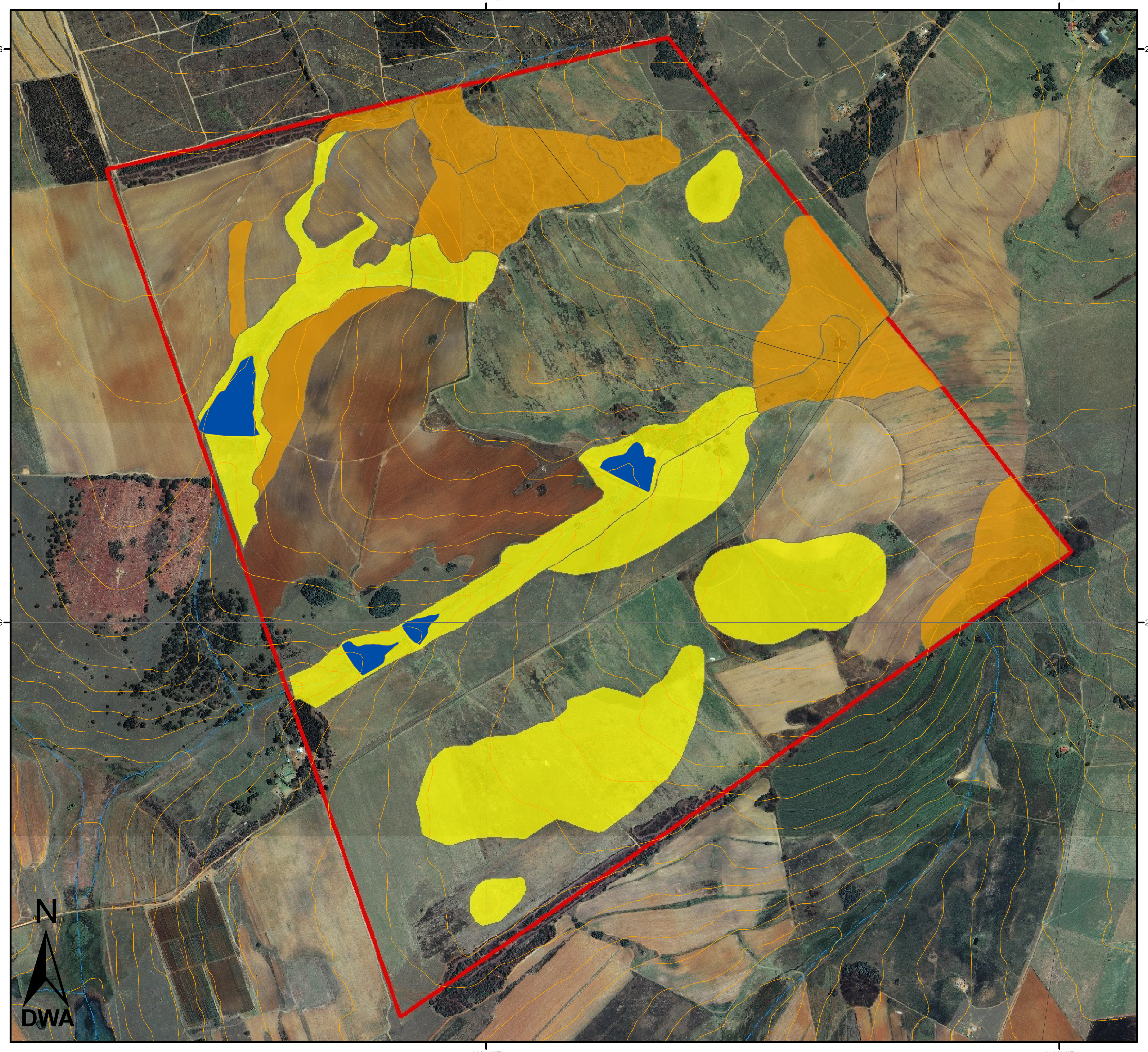
Projection: Transverse Mercator
Central Meridian: Lo31
Datum: WGS84

1:12,000

0 75 150 300 450 600
Meters

Ref:/glo.NOR335.200807.007

Appendix D: The Ecological Importance and Sensitivity (EIS) of wetlands associated with the study area



Plan 3

Northern Coal Weltevreden

Ecolgocal Importance & Sensitivity

Legend

Weltevreden Site

5m Contours

Wetland delineation

EIS C

EIS D

Dams

Minor Road

Perennial Stream

Non-Perennial Stream

DWA

Projection: Transverse Mercator
Central Meridian: Lo31
Datum: WGS84

1:12,000

0 75 150 300 450 600
Meters

Ref:/bjt.NOR335.200806.001

Appendix E: Photographs taken from within the study area.

Hydric indicators associated with wetland soils in the study area.

Imperata cylindrica, vegetation used as a wetland indicator.

Hillslope seepage wetland connected to the valley bottom wetland in the study area

One of the dams located within the study area