WETLAND SPECIALIST ASSESSMENT

FOR THE PROPOSED

PLATREEF UNDERGROUND MINE

PLATREEF RESOURCES (PTY) LTD

DECEMBER 2013

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This document has been prepared by **Digby Wells Environmental**.

Report Title: **Wetland Specialist Assessment for the proposed Platreef Underground Mine**

Project Number: **PLA1677**

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ACRONYMS

AEMC	–	Attainable Ecological Management Class
CV	–	Curriculum vitae
DEMC	–	Default Ecological Management Class
Digby Wells	–	Digby Wells Environmental
DWAF	–	Department of Water Affairs and Forestry
EISC	–	Ecological Importance and Sensitivity Category
NWA	–	National Water Act
PESC	–	Present Ecological State Category
TSF	–	Tailings Storage Facility
WMA	–	Water Management Area

EXECUTIVE SUMMARY

Digby Wells Environmental was commissioned by Platreef Resources (Pty) Ltd to conduct a wetland specialist assessment for the Platreef Underground Mining Project. The specialist study aimed to identify and assess the ecological relevance of the surface water ecosystems associated with the study area.

The study area is located west of Mokopane in the Limpopo Province. The study area is located within the Limpopo Water Management Area (WMA) and is situated within quaternary catchments A61F and A61G. The south western project boundary is defined by the Mogalakwena River.

The wetland delineation guidelines published by the Department of Water Affairs and Forestry (DWAF) were used for the project. Wetland systems and riparian areas were delineated accordingly. The ecological services as well as the integrity (health) of the local wetland systems were also assessed. In impact study was conducted for the local wetland system in light of the proposed underground mining operation.

The Mogalakwena River system was identified as a floodplain system and assessed accordingly. The Rooisloot, Ngwaditse and Dithokeng rivers are ephemeral systems whereby the riparian areas were delineated in order to determine the extent of these systems. No ecological services considered to be of low or moderately low importance were identified for the system. The majority of the ecological services provided by the Mogalakwena River floodplain were determined to be of moderately high importance. These services are attributed to the enhancement of water quality with the removal of phosphates as well as by removing nitrates and toxicants. The dependence of the local communities on the system is indicated by the high importance of selected services. These services pertain largely to water supply and food resources. The water of the floodplain is used for drinking, cooking, cleaning and watering of plantations.

The current land-uses have impacted on the functioning of this system. Local agricultural practices, pertaining predominantly to livestock have impacted on the ability of this system to provide important services. Agricultural activities have altered the natural hydrology of the system. The decrease in surface roughness due to overgrazing has resulted in a potentially destructive hydrological regime for the system. In addition to this, livestock also impact directly on the quality of water as a result of nutrient input and trampling of the system.

The overall integrity of the wetland system was determined to be moderately modified and the current health of the system is expected to remain stable over the next five years. The deterioration of the system may be predominantly attributed to the continued agricultural practices being implemented.

The mining method to be employed for the project is the sublevel blast hole stoping which, along with any of the shafts or surface infrastructure it is not anticipated to impact on any of the wetlands, with the exception of the proposed Tailings Storage Facility (TSF) locations.

Owing to these factors, no direct impacts on the wetlands, other than the TSF, are expected due to habitat loss.

The risk of subsidence is the greatest potential threat to wetlands identified for the project. As a consequence of this, the hydrological regime may be altered from their natural state. It has been recommended that the geotechnical stability assessment submitted provide exact recommended specifications for stoping methodology. These should be strictly adhered to in order to prevent potential subsidence. A buffer zone of 100m has been allocated to all wetland areas, this is to be applied for Site 2 of the TSF options, this is the preferred site. Consideration has been given to the General Authorisation published by the Department of Water Affairs in relation to section 21(c) and 21(i) water uses in the National Water Act. Owing to the fact that selected activities are expected to take place within 500m of the wetland areas, a Water Use Licence is expected to be required.

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1. INTRODUCTION

An integrated specialist assessment of the project area was conducted in order to identify any aquatic ecosystems associated with the study area and to then potentially assess the ecological relevance of these surface water ecosystems. This study consisted of an assessment of the lentic systems where possible, notably wetland ecosystems. According to the National Water Act, 1998 (Act No. 36 of 1998) (NWA), 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 NWA. 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. The two aquatic ecosystems which were assessed for this study were wetland and river systems.

The lentic system (wetland) which was assessed for the study was the floodplain system associated with the Mogalakwena River. The importance of this floodplain system may be attributed to the location of the Nylsvlei Ramsar site in the upper catchment of the Nyl River. The Nyl River is situated in the Limpopo Province of South Africa and represents the southernmost tributary of the Mogalakwena River (Birkhead *et al*., 2007). The Nyl River passes through the Nyl River floodplain, known as 'Nylsvlei'. According to Higgins *et al*. (1996) the floodplain is a unique and a highly biologically productive ecological system. The system is recognised internationally as an important wetland due to the large size and the variety of wildlife supported by the system, including several Red Data bird species (Birkhead *et al*., 2007). An increase in water resource developments in the upper catchment areas is threatening the ecological status of the floodplain. Although the proposed project area may not directly impact on the ecological state and functioning of the Nyl River floodplain, impacts may be incurred onto the Mogalakwena River floodplain, a beneficiary of the Nyl River floodplain. Due to this, the ecological functioning and integrity (health) of the Mogalakwena River floodplain was important to consider.

The practical field procedure for identification and delineation of wetlands and riparian areas described by the Department of Water Affairs and Forestry (DWAF) was implemented for this study. This specialist study attempted to describe the ecological services provided by the various systems and the importance thereof. In addition to this, a further specialist study component of the integrated assessment included an ecological state assessment of the Mogalakwena River floodplain only. A technique for rapidly assessing ecosystem services supplied by wetlands (WET-EcoServices) was implemented to identify and describe the ecological services provided. WET-Health was implemented to assist in assessing the health of the floodplain system using various indicators.

For the purpose of this study, the wetland systems were considered as the ecosystems defined by the NWA 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."

The riparian areas were delineated in order to identify the lotic systems for the catchment. Owing to the fact that these systems are non-perennial, an ecological services and state assessment was not conducted. The National Water Act defines a riparian habitat as follows:

"Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas."

The output scores from the indices are presented in the standard DWAF A - F ecological categories. 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 categories applied in this study were modified from Kleynhans (1996 and 1999). The results from the individual indices are presented in the form of ecological state categories, these categories range from an "A" to an "F" state. The ecological state category as well as the rating and description per category are presented in Table 1-1.

Table 1-1: The ecological state categories, categories, key colours and category descriptions

Category	Rating	Category description
A	Very good	*Unmodified state* – Un-impacted state, conditions natural.
B	Good	*Largely natural* – Small change in community characteristics, most aspects natural.
C	Moderate	*Moderately modified* – Clear community modifications, some impairment of health evident.
D	Poor	*Largely modified* – Impairment of health clearly evident. Unacceptably impacted state.
E	Very poor	*Seriously modified* – Most community characteristics seriously modified. Unacceptable state.
F	Critical	*Critically modified* – Extremely low species diversity. Unacceptable state.

This report presents the results obtained from the wetland specialist assessment for the Platreef Project conducted during November 2011, and the impact assessment completed in October 2013. The report is comprised of a wetland delineation, ecological services *description as well as an ecological integrity assessment for selected systems. Findings from this study constitute baseline information for the project area.*

2. TERMS OF REFERENCE

Digby Wells Environmental (Digby Wells) was commissioned by Platreef Resources (Pty) Ltd to conduct a wetland specialist assessment for the Platreef Underground Mining Project. The specialist study aimed to identify and assess the ecological relevance of the surface water ecosystems associated with the study area. This assessment was conducted in order to collate baseline information for the project with particular consideration for the National Water Act, 1998 (Act No. 36 of 1998).

A baseline investigation was completed by Digby Wells in November 2011. These findings were then again ground truthed in September 2013, which have been incorporated to the impact assessment completed in October 2013.

3. KNOWLEDGE GAPS

The Rooisloot, Ngwaditse and Dithokeng rivers are ephemeral systems and were dry, with isolated pools of standing water during the survey period. Photographs of the dry rivers experienced during the survey are presented in Figure 3-1. As a result of this, an ecological state assessment could not be conducted for these systems. In light of this, only the riparian areas associated with these systems were delineated in order to determine the location and extent of these systems with reference to the project area.

Rooisloot River | Ngwaditse River | Dithokeng River

Figure 3-1: Photographs of the dry river systems identified during the survey

4. STUDY AREA

The study area is located west of Mokopane in the Limpopo Province. The study area is located within the Limpopo Water Management Area (WMA 1) and is situated within the quaternary catchments A61F and A61G. The south western project boundary is defined by the Mogalakwena River. The location of the Mogalakwena River floodplain study area downstream and in relation to the Nylsvlei Ramsar site within the Limpopo WMA is presented in Figure 4-1.

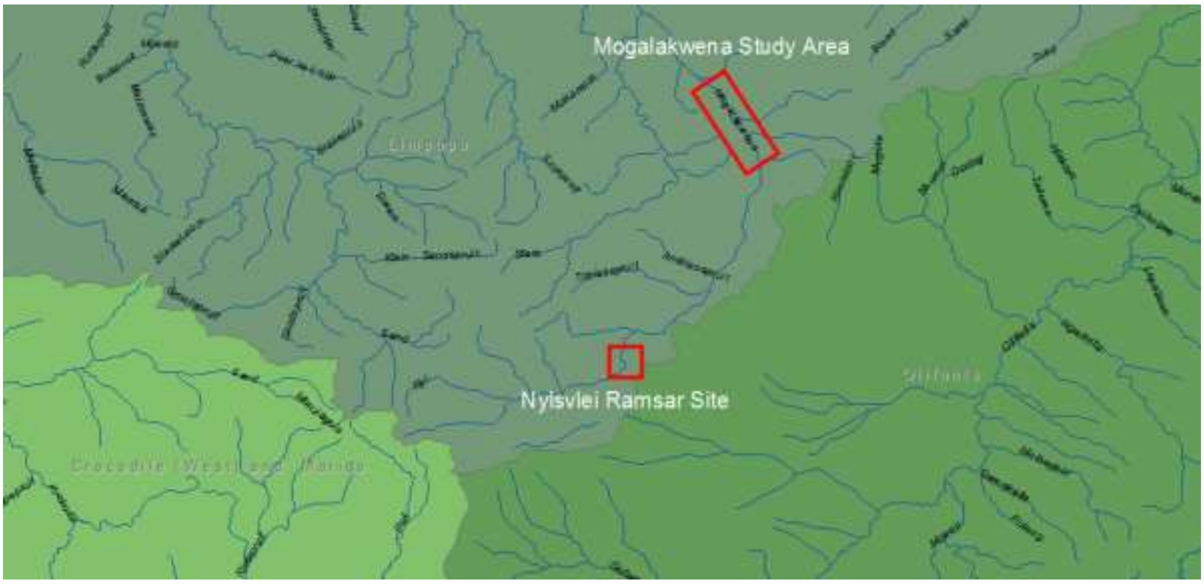

Figure 4-1: The location of the Mogalakwena study area in relation to the Nylsvlei Ramsar site within the Limpopo Water Management Area

The location of the Rooisloot, Ngwaditse and Dithokeng rivers which all transect the study area in relation to the project area within the respective quaternary catchments is presented in Figure 4-2.

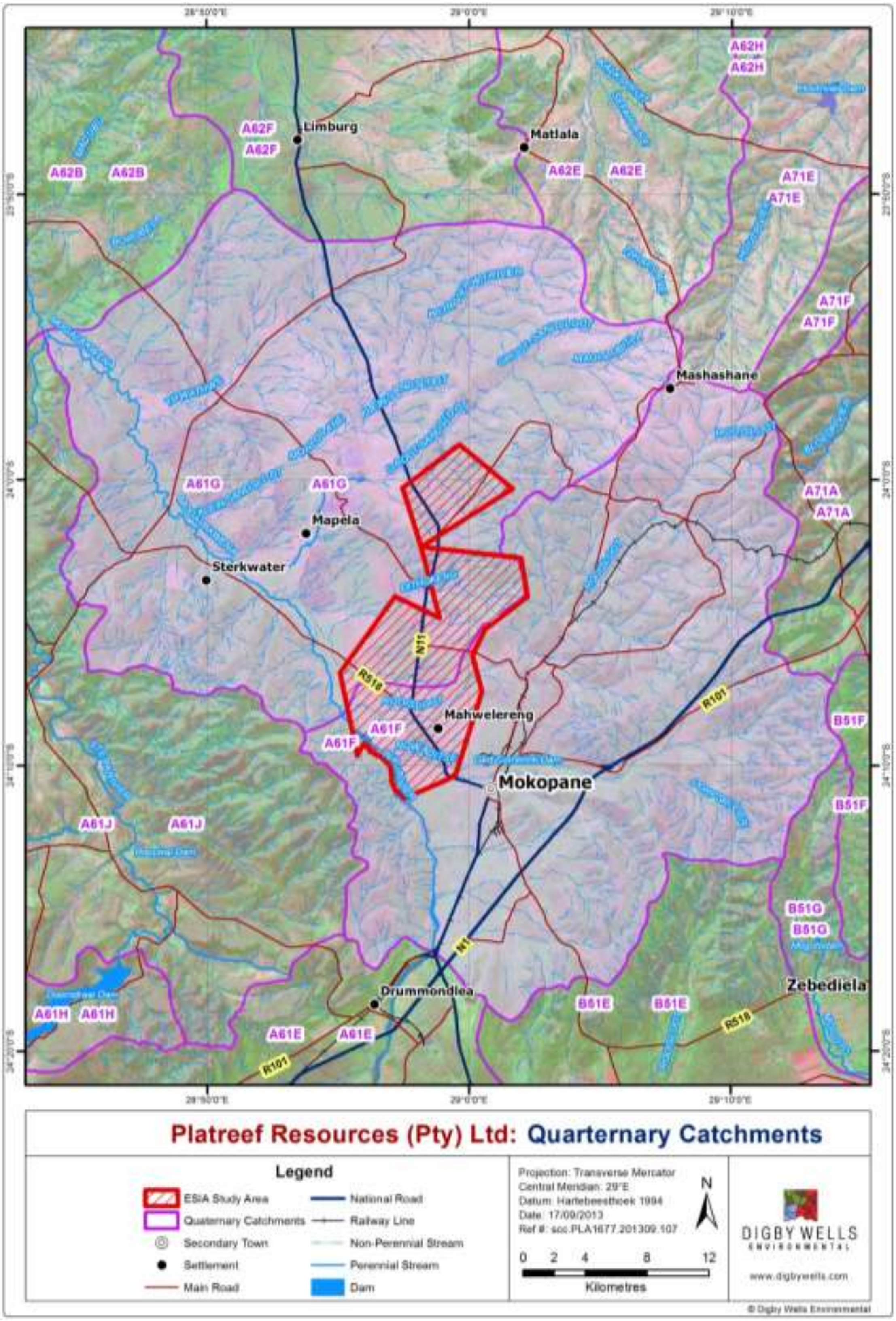

Figure 4-2: The location of the Rooisloot, Ngwaditse and Dithokeng rivers in relation to the study area

According to the ecological importance classification for the quaternary catchments A61F and A61G the Mogalakwena River floodplain system is classified as a moderate system which in its present state can be considered to be a Class B (Largely natural) system. The default ecological management class for the relevant quaternary catchments is considered to be moderately sensitive system. The attainable ecological management class for the system is a Class B (Largely natural). A summary of the ecological integrity (health) and management categories for the Mogalakwena River floodplain in quaternary catchments A61F and A61G is presented in Table 4-1.

Table 4-1: The ecological and management categories for quaternary catchments A61F and A61G (Kleynhans, 2000)

Category	Description	State
EISC	Ecological importance and sensitivity category	Moderate
DEMC	Default ecological management class	Moderately sensitive systems
PESC	Present ecological status category	Class B: Largely natural
AEMC	Attainable ecological management class	Class B: Largely natural

5. EXPERTISE OF THE SPECIALIST

A curriculum vitae (CV) is attached in Appendix A

6. AIMS AND OBJECTIVES

The aim of the aquatic ecosystems assessment was to determine the location and extent of the systems with reference to the study area as well as to assess the ecological relevance of the identified systems. In order to achieve this aim the following objectives were considered:

- The identification, characterization and delineation of the wetland systems;
- The description of ecological services (WET-EcoServices) provided by the Mogalakwena River floodplain;
- Determine the health of the Mogalakwena River floodplain by use of indicators (WET-Health); and
- A specialist impact assessment for the proposed project.

7. METHODOLOGY

7.1. Wetland Identification and Mapping

Maps were generated from aerial photographs, onto which the aquatic ecosystem boundaries were delineated. A site visit was undertaken in November 2011 to the project area for orientation and ground truthing. In order to determine the boundaries of the aquatic ecosystems, the methodology described by DWAF (2005) was adopted. This included a desktop delineation by estimating system boundaries from aerial photos, making use of topography, the presence of water and different vegetation structure as indicators. Findings from a soil study conducted for the area was used to supplement this specialist survey.

7.2. Floodplain Delineation

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

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

7.3. Riparian Delineation

Riparian areas have their own unique set of indicators which are used to delineate riparian areas. Further descriptions on the three indicators are presented in Appendix B. The delineation process requires that the following be taken into account:

- Topography associated with the watercourse;
- Vegetation; and
- Alluvial soils and deposited material.

7.4. Wetland Functional Assessment

In accordance with the method described by Kotze *et al*. (2007), a Level II ecological functional assessment of the floodplain system was undertaken. This methodology provides for a scoring system to establish the services of the ecosystem. The functional assessment technique, WET-EcoServices, developed by Kotze *et al.*, (2007) was implemented to provide an indication of the benefits and services of the system.

7.5. Determining the Ecological Integrity of the Wetlands

In order to determine the integrity (health) of the floodplain system, the WET-Health tool was applied. According to Macfarlane *et al*. (2009) the health of a wetland can be defined as a measure of the deviation of wetland structure and function from the wetland’s natural reference condition. The health assessment attempts to assess hydrological, geomorphological and vegetation health in three separate modules in order to attempt to estimate similarity to or deviation from natural conditions. The tool is structured such that a low score (close to 0) provides an indication of good health, while a high score (close to 10) provides an indication of poor health as shown in Table 7-1. The overall approach of the assessment was to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a present state score. A Level II WET-Health assessment was conducted for this study for the floodplain.

Table 7-1: Health categories used by WET-Health for describing the integrity of wetlands

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

7.6. Ecological classification and description

Ecological classification refers to the determination and categorisation of the integrity of the various selected biophysical attributes of ecosystems compared to the natural or close to natural reference conditions (Kleynhans and Louw, 2007). The ecological evaluation in terms of expected reference conditions, followed by integration of these components and assessed in terms of biological responses, represents the Ecological Status or EcoStatus of a system (Kleynhans and Louw, 2007). According to Iversen *et al*. (2000) EcoStatus may be defined as the totality of the features and characteristics of the system that bear upon its ability to support an appropriate natural flora and fauna.

According to Kleynhans and Louw (2007) the A to F scale represents a continuum and that the boundaries between categories are notional, artificially-defined points along the continuum. As a result of this there may be uncertainty regarding which category a particular entity belongs to. This situation falls within the concept of a fuzzy boundary, where a particular entity may potentially have membership of both classes (Robertson *et al*., 2004). For practical purposes these situations are referred to as boundary categories and are denoted as B/C, C/D, and so on. The wetlands studied fell within the category B. An illustration of the distribution of the ecological categories on a continuum (Kleynhans and Louw, 2007) is presented in Figure 7-1.

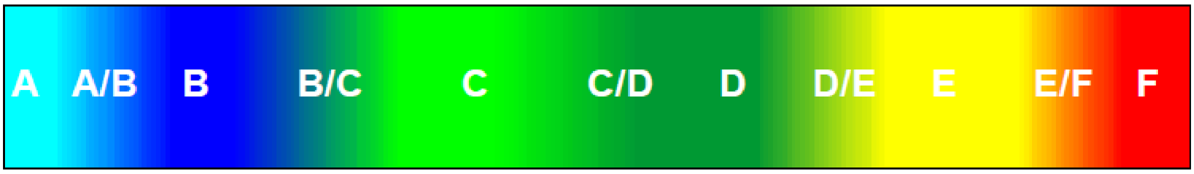

Figure 7-1: An illustration of the distribution of the ecological categories on a continuum

8. RESULTS AND DISCUSSION

The Mogalakwena River system was identified as a floodplain system and assessed accordingly. According to Marneweck and Batchelor (2002) floodplains can be defined as low-gradient land onto which a river regularly overflows its banks, usually seasonally or during periods of high rainfall in the catchment with a relatively level alluvial (sand or gravel) area lying adjacent to the river channel, which has been constructed by the present river in its existing regime. The description of the floodplain according to Kotze *et al*. (2004) based on the setting in the landscape and hydrologic components is presented in Table 8-1.

Table 8-1: The definition of the wetland unit occurring in the study area further developed by Kotze *et al*. (2004).

System	Topographic	Description
Floodplain	In depressions and basins, often at drainage divides on top of the hills	Valley bottom areas without a stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvial transport and deposition of sediment, usually leading to a net accumulation of sediment.
Hydrological components		
Inputs	**Throughputs**	**Outputs**
From main channel (when channel banks over spill) and from adjacent slopes.	Interflow and diffuse surface flow.	Variable but predominantly stream flow.

The Rooisloot, Ngwaditse and Dithokeng rivers are ephemeral systems whereby the riparian areas were delineated in order to determine the extent of these systems. According to DWAF (2005) riparian areas include plant communities adjacent to and affected by surface and subsurface hydrologic features and these include rivers, streams, lakes, or drainage ways. In addition to this, both perennial and non-perennial streams support riparian vegetation. These river systems have been referred to as channelled valley bottom systems as result of the defined channel for each system.

The identified Mogalakwena River floodplain system as well as the delineated riparian areas for the Rooisloot, Ngwaditse and Dithokeng rivers is presented in Figure 8-1.

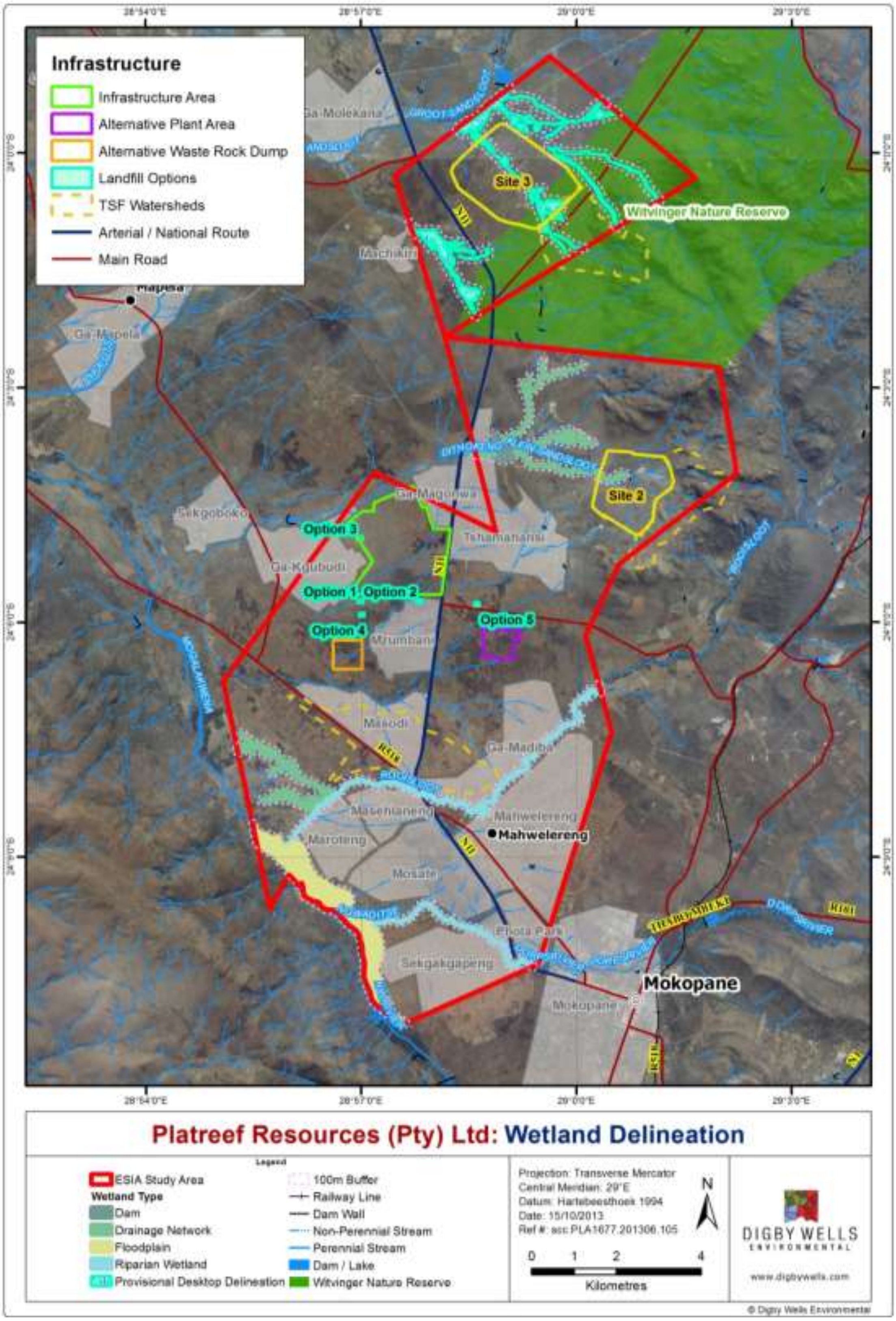

Figure 8-1: The delineated Mogalakwena River floodplain system and the Rooisloot, Ngwaditse and Dithokeng rivers riparian areas for the project area

8.1. General Description of the Systems

8.1.1. The floodplains

The floodplain surface usually slopes away from the channel margins as a result of preferential sediment deposition along the channel edges and areas closest to the channel the floodplain surface usually slopes away from the channel margins which can then result in the formation of backwater swamps at the edges of the floodplain margins (DWAF, 2007). According to Kotze *et al*. (2007) floodplains usually receive most of their water during high flow events when waters overtop the stream banks. According to McCartney (2000) flood attenuation is likely to be high early in the season until the floodplain soils are saturated and the oxbows and other depressions are filled. Additionally, the flood attenuation capacity is drastically reduced in the late season. It is unlikely that floodplains contribute significantly to stream flow regulation (Kotze *et al*., 2007). The contribution of water from floodplains to stream flow and groundwater recharge is limited as a result of the clayey floodplain soils which retain water (Kotze *et al*., 2007). Generally the inundation period of floodplains is short but in the oxbow depression portions of the floodplain inundation is more prolonged. Floodplains also assist with the enhancement of water quality but this is limited due to short residence times during flood events and due to the limited sub-surface water movement within the wetland.

8.1.2. Channelled valley bottom systems

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

8.2. General Functional Dscription of the Systems

8.2.1. The floodplain

According to Kotze *et al*. (2007) floodplains are considered to be important for flood attenuation because of the nature of the vegetation and the topographic setting that they occupy. The velocity of flow decreases laterally as the flood overtops the river banks, thus allowing for the deposition of particles within the floodplain landscape (Kotze *et al*, (2007). According to Hemond and Benoit (1998) phosphorous and other toxicants bound to trapped sediment are likely to be retained on the floodplains and this is a vital mechanism through which wetlands trap phosphates. According to Kotze *et al*. (2007) nitrogen removal via nitrification/denitrification is likely but also limited due to the short flooding periods. Additionally, due to the dilution effects the concentration of nutrients in flood waters entering the floodplain is often low (Kotze *et al*., 2007).

8.2.2. Channelled valley bottom systems

A key benefit of the valley bottom wetlands with channels associated with both farms is the enhancement to the quality of water. According to Kotze at al. (2007) these wetlands contribute less towards flood attenuation and sediment trapping, but would supply these benefits to a certain extent. These wetlands would thus provide a service through limited flood attenuation by the spreading out and the slowing down of floodwater in the wetland, thereby reducing the severity of floods downstream and by trapping and the retention in the wetland itself of sediment carried by runoff waters. Additionally, these wetlands would offer some nitrate and phosphate removal potential, particularly from the water being delivered from the adjacent hillslopes (The Federal Interagency Stream Restoration Working Group, 1998).

8.3. Floodplain Functional Description

The general features of the wetland units were assessed in terms of functioning and the overall importance of the hydro-geomorphic units were then determined at a landscape level.

The level of functioning supplied by the Mogalakwena River floodplain for various ecological services for the project area is presented in Table 8-2. The result from the "WET-EcoServices" tool for the respective wetland unit is presented below in Figure 8-2. Table 8 3 presents the percentage of the five ecological services classes for the respective wetland systems assessed.

Table 8-2: A listing and scoring of ecological services offered by the Mogalakwena River floodplain identified for the study area

Ecological Services	Floodplain
Flood attenuation	2.3
Streamflow regulation	2.8
Sediment trapping	2.3
Phospahte trapping	2.7
Nitrate removal	2.7
Toxicant removal	2.9
Erosion control	2.3
Carbon storage	2.3
Maintenance of biodiversity	3.8
Water supply for human use	3.5
Natural resources	4.0
Cultivated foods	3.6
Cultural significance	2.5
Tourism and recreation	3.4
Education and research	2.5

Note: <0.5 Low 0.5-1.5 Moderately low .5-2.5 Intermediate 5-3.5 Moderately high .5 High

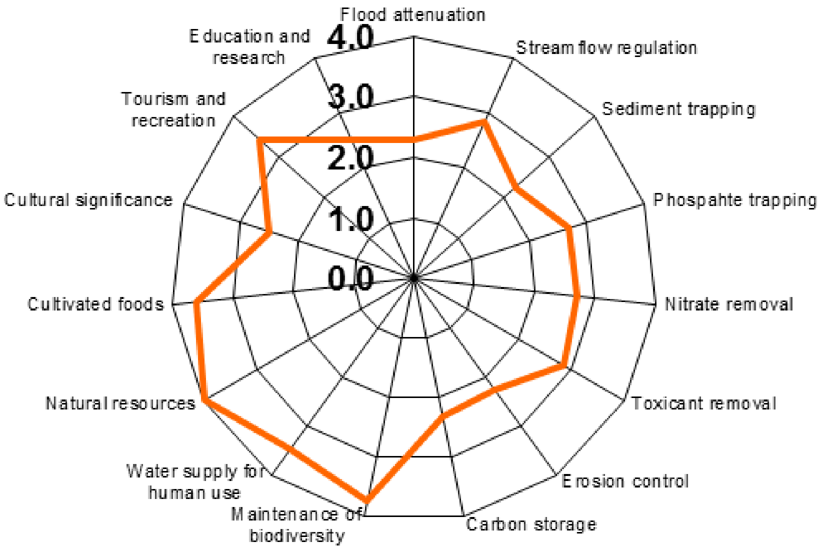

Figure 8-2: Radial plots of functions performed by the floodplain system

The layout of the radial plot for the floodplain system indicates the importance and dependence by the local communities on the system for varying resources. In addition to this, the system also has the ability to enhance water quality. This is important to note when considering the local land-uses and surrounding activities impacting on the water quality of the system.

Table 8-3: A list of the percentage of each importance class for the provided services

Ecological Services	Floodplain
Low	0%
Moderately low	0%
Intermediate	27%
Moderately high	46%
High	27%

No ecological services considered to be of low or moderately low importance were identified for the system (Table 8-3). The majority of the ecological services (46%) provided by the Mogalakwena River floodplain was determined to be of moderately high importance. These services may be attributed to the enhancement of water quality with the removal of phosphates as well as by removing nitrates and toxicants. Owing to the dependence of the local communities on the system, it is likely that there is an important cultural relationship with the community and the system. The floodplain is adjacent to the Waterberg Wilderness Reserve which indicates the importance of this system to provide both tourism and recreational activities such as fishing and birding. In addition to the above mentioned services, there is an important opportunity to conduct further research into the system, especially considering the ecological significance of the Nylsvlei Ramsar site in the upper catchment areas and the relationship between the two systems.

The dependence of the local communities on the system is indicated by the high importance of selected services. These services pertain largely to water supply and food resources. The water of the floodplain is used for drinking, cooking, cleaning and watering of plantations. In addition to this, the system is also fished by locals for food. An additional service identified to be of a high importance and not directly beneficial to the local communities is the maintenance of biodiversity. This is further supported with the location of the Waterberg Wilderness Reserve on the periphery of the system.

The current land-uses have impacted on the functioning of this system. Local agricultural practices, pertaining predominantly to livestock have impacted on the ability of this system to provide important services. Agricultural activities have altered the natural hydrology of the system. The decrease in surface roughness due to overgrazing has resulted in a potentially destructive hydrological regime for the system. In addition to this, livestock also impact directly on the quality of water as a result of nutrient input and trampling of the system. Owing to the fact that agricultural practices are on-going for the project area, coupled by the absence of mitigatory measures for the current land-uses, it is assumed that the ability of the units to provide important ecological services will continue to deteriorate. The severity of the current identified impacts was however determined to be minor at this stage. Photographs of threats to the ecological functioning of the floodplain are presented in Figure 8-3.

Livetstock and cattle paths

Hydrological alterations

Overgrazing

Figure 8-3: Photographs of threats to the ecological functioning of the system

8.4. The Ecological Health Aassessment of the Floodplain

The health assessment of the identified floodplain system made use of the indicators hydrology, geomorphology and vegetation. The findings of the WET-Health assessment for the three indicators are presented in Table 8-4. In spite of being discouraged to aggregate the scores for the three study components, an overall health assessment of the system was required. Thus, the adopted formula is as follows:

((Hydrology score) x 3 + (geomorphology score) x 2 + (Vegetation score) x 2) ÷7

The rationale for this formula is that hydrology is considered to have the greatest contribution to health of the system. This formula provides a score ranging from 0 (pristine) to 10 (critically impacted in all respects).

Table 8-4: A summary of the WET-Health scores for the study components

Module	Impact Score	Category	Change Score	Trajectory	Health Class
Hydrology	2.4	C	0	→	C→
Geomorphology	2.6	C	0	↓	C↓
Vegetation	2.1	C	0	↓	C↓
Overall Score	**2.1**	**C**	**0**	→	**C→**

The hydrological impacts associated with the floodplain system were identifiable, but limited (Category C). Alterations to the hydrological regime may largely be attributed to the placement of dams upstream of the system. The overgrazing of the catchment by livestock has altered the run-off pattern for the catchment. The local land-uses have contributed to the erosion and formation of headcuts within the system. The loss of surface roughness, local agricultural activities and increased erodibility of the catchment has modified the hydrology of the catchment. In spite of these impacts, the hydrological condition of the assessed catchment is likely to remain stable over the next five years.

The geomorphology of the wetland was determined to be moderately modified with a moderate change in geomorphic processes which has taken place but the system remains predominantly intact. The changes to the hydrological regime for the catchment, as well as considering the local land-uses have indirectly impacted on the geomorphology of the system. The diffuse nature of the system has been reduced due to agricultural practices, resulting in erosion of selected areas as well as increasing the erosion potential of the areas. The run-off potential of the system has also increased due to the agricultural practices within the system, impacting on the overall geomorphology. The erosion and formation of headcuts is evident and are encroaching into the upper catchment areas. The trajectory change for the geomorphological condition of the system is likely to deteriorate slightly over the next five years and this may be attributed to the continuation of the poorly managed land-uses.

The vegetation composition associated with the catchment area was determined to be moderately altered but introduced alien and/or ruderal species are still clearly less abundant than characteristic indigenous wetland species (Category C). Changes to the vegetative structure for the system may largely be attributed to agricultural practices, such as overgrazing and field clearings. This has resulted in the removal of indigenous plant species. The trajectory change for the vegetation condition of the system is likely to deteriorate over the next five years.

The overall integrity of the wetland system was determined to be moderately modified (Category C) and the current health of the system is expected to remain stable over the next five years. The deterioration of the system may be predominantly attributed to the continued agricultural practices being implemented. The pressures imposed onto the catchment are a concern and in order for the integrity of the catchment to be improved, these land-uses should be better managed and the mitigatory measures implemented.

9. IMPACTS ASSESSMENT

The impact table considered for the study is presented in Table 9-1. The significance rating for the identified potential impacts and associated description for the significance for each impact are presented in Table 9-2 and Table 9-3 respectively.

Table 9-1: The impact table for the proposed Platreef Underground Mine

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

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

Table 9-2: The significance rating for each potential impact

Significance

Consequence (severity + scale + duration)

Probability / Likelihood		1	3	5	7	9	11	15	18	21
	1	1	3	5	7	9	11	15	18	21
	2	2	6	10	14	18	22	30	36	42
	3	3	9	15	21	27	33	45	54	63
	4	4	12	20	28	36	44	60	72	84
	5	5	15	25	35	45	55	75	90	105
	6	6	18	30	42	54	66	90	108	126
	7	7	21	35	49	63	77	105	126	147

Table 9-3: A description of the significance classes for each impact

Significance		
High (Major)	**108- 147**	
Medium-High (Moderate)	**73 – 107**	
Medium-Low (Minor)	**36 – 72**	
Low (Negligible)	**0 – 35**	

The table below (Table 9-4) describes the various activities associated with the respective phases of mining proposed for the Platreef Underground Mine.

Table 9-4: Mining activities for the proposed Platreef Underground Mine

Activity No.	Activity
1	Site Clearing: removal of topsoil and vegetation.
2	Construction of any surface infrastructure e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks etc. (including transportation of materials and stockpiling).
3	Transportation of materials & workers on site.
4	Temporary storage of hazardous chemicals and fuels.
5	Removal PGM's (underground mining process).
6	Operation of surface infrastructure such as the operation of the mining shaft, crusher, pipelines, the TSF and processing plant (includes water use and storage on site, including pollution control dams).
7	Storage, handling and treatment of hazardous products (fuel, explosives, oil) and waste activities (waste, sewage, discards, PCD).
8	Demolition & removal of all infrastructures (incl. transportation off site).
9	Rehabilitation (spreading of soil, re-vegetation & profiling/contouring) (includes sealing of adit and ventilation shaft entrances).
10	Storage, handling and treatment of hazardous products (fuel, explosives, oil) and waste activities (waste and sewage).
11	Post-closure monitoring and rehabilitation.

9.1. Aspect and Impacts

9.1.1. Aspect and impacts of current land use (the no-go option)

The current land-use activities within the proposed Platreef Underground Mine area are mainly sand-mining and livestock farming. The diffuse nature of the wetlands on site has been reduced and headcut erosion has taken place. Livestock overgrazing and trampling has also contributed to erosion in wetland systems. The water quality of the systems on site has been impacted on due to sewage effluent. Continued agricultural activities on site will result in transformation of wetlands and areas adjacent to wetlands to a disturbed state, thus reducing biodiversity, promoting the processes of erosion and reducing the capacity of wetlands to produce EcoServices such as nutrient cycling, water purification and flood attenuation.

9.1.1.1. Aspect 1: Direct loss of wetlands

As a result of the loss of wetland areas to sand-mining, the associated wetland vegetation has also been impacted.

- Impact 1: Loss of hillslope seepage wetland; and
- Impact 2: Loss of wetland integrity

Issue 1	**Direct loss of wetland areas**				
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 1	**Loss of hillslope seepage wetlands**				
Pre- Mitigation	Minor (2)	Local (2)	Permanent (6)	Probable (4)	Medium-Low (36)
Post- Mitigation	N/A				
Impact 2	**Loss of wetland integrity**				
Pre- Mitigation	Moderate (3)	Local (2)	Permanent (6)	Probably (4)	Medium-Low (44)
Post- Mitigation	N/A				

9.1.1.2. Aspect 2: Loss of wetland integrity and functionality

Damming, cannalisation and erosion have caused an unfavourable alteration to the hydrology and geomorphology of the wetlands on site. The establishment of alien plant species has resulted in a loss of vegetation integrity due to the decrease in biodiversity associated with this. Sewage effluent has resulted in the contamination of the water associated with the wetland areas.

- Impact 3: Loss of wetland vegetation communities;
- Impact 4: Contamination of surface water, and;
- Impact 5: Changes in natural wetland drainage patterns.

Issue 2	**Loss of wetland integrity and functionality**				
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 3	**Loss of wetland vegetation communities**				
Pre- Mitigation	Moderate (3)	Local (3)	Permanent (6)	Likely (5)	Medium-Low (55)
Post- Mitigation	N/A				
Impact 4	**Contamination of surface water**				
Pre- Mitigation	Very Serious (5)	Municipal (4)	Permanent (6)	Probable (4)	Medium-Low (60)
Post- Mitigation	N/A				
Impact 5	**Changes in natural wetland drainage patterns**				
Pre-Mitigation	Serious (4)	Municipal (4)	Permanent (6)	Likely (5)	Medium- High (70)
Post- Mitigation	N/A				

9.1.2. Impact of the proposed mining activity

The impact assessment for the proposed Platreef Underground Mine primarily considered the proposed underground mining method, as well as the proposed surface infrastructure with the key focus being afforded to the options being considered for the TSF. These are discussed in greater detail in the subsequent sections. The mine plan in respect to the delineated systems is presented in Figure 9-1.

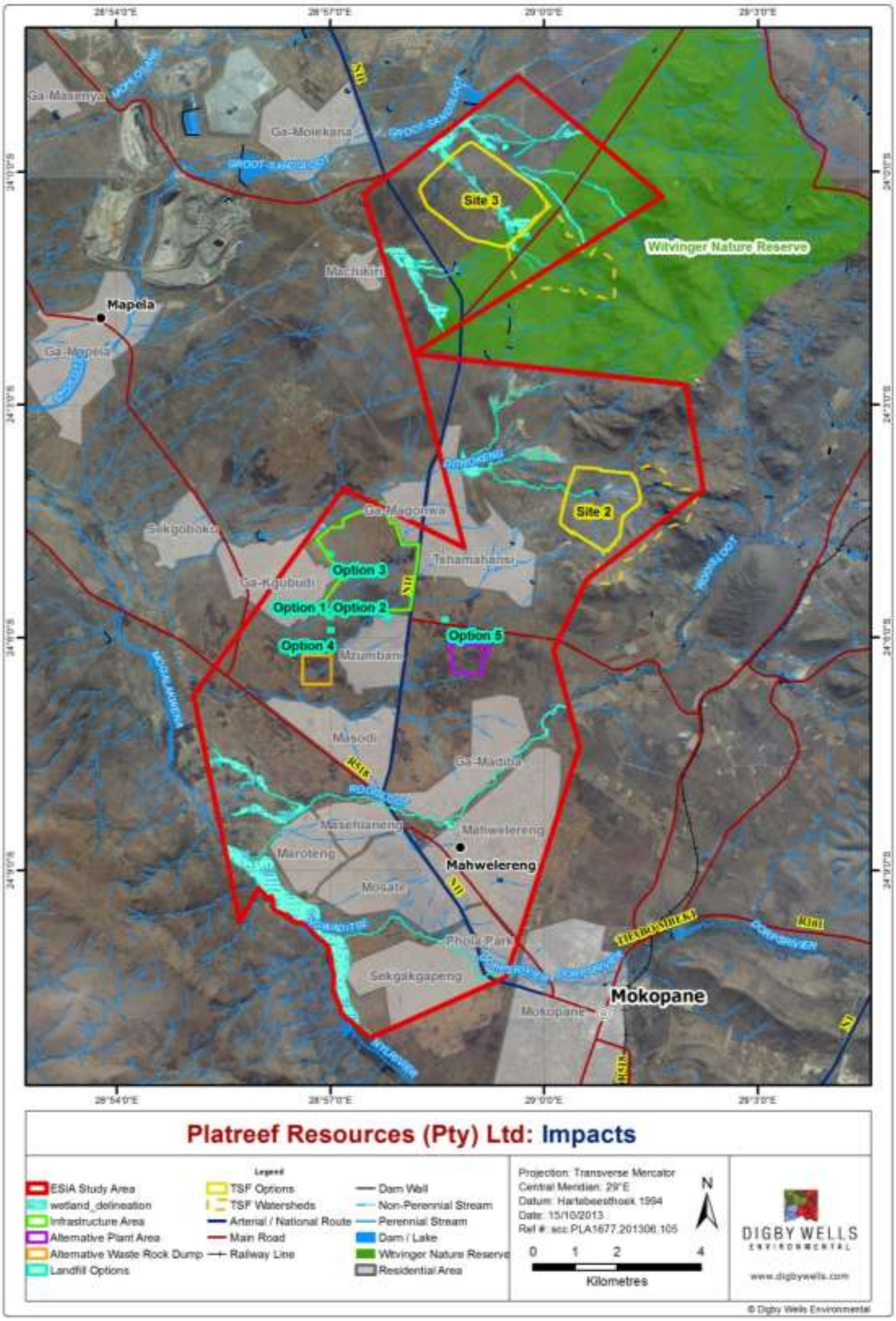

Figure 9-1: The mine plan in relation to the local wetland systems

9.1.2.1. Aspect 1: Direct loss of wetland areas

The mining method to be employed for the Platreef underground mine is the sublevel blast hole stoping method. As the mining will take place underground, it is also anticipated that none of the shafts or surface infrastructure with the exception of the proposed TSF options will coincide with any wetland areas, the impacts on wetlands are expected to be minimal. A preferred location for the TSF will be recommended. It should be noted, however, that appropriate *geotechnical investigations* should be conducted in order to determine the potential for subsidence of the area due to the mining operation, as well as prescribing recommendations in order to avoid or in the least mitigate surface impacts.

- Impact 1: Removal of wetland areas
- Impact 2: Loss of ecological services

Issue 1	**Loss of wetland areas**				
Phase	***Construction***	***Operation***	***Closure***		
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 1	**Removal of wetland areas**				
Pre- Mitigation	Moderate (3)	Local (3)	Permanent (6)	Likely (5)	Medium-Low (55)
Post- Mitigation	Minor (2)	Local (2)	Permanent (6)	Probable (4)	Medium-Low (36)
Impact 2	**Loss of ecological services**				
Pre- Mitigation	Moderate (3)	Local (3)	Permanent (6)	Likely (5)	Medium-Low (60)
Post- Mitigation	Moderate (3)	Local (2)	Permanent (6)	Probable (4)	Medium-Low (44)

9.1.2.2. Aspect 2: Risk of subsidence

The risk of subsidence is the greatest potential threat to wetlands identified for the Platreef Underground Mine. Due to the removal of minerals via sublevel blast hole stoping methods, subsidence is a potential risk. As a consequence of this, flow patterns will be altered from their natural state. Further to this, fissures or fractures in rock mined out voids may occur due to blasting. If these rock layers are associated with wetlands, potential vertical seepage from wetlands may occur.

- Impact 3: Changes to hydrological regimes
- Impact 4: Loss of ecological services

Issue 1	**Risk of subsidence**				
Phase	***Construction***	***Operation***	***Closure***		
Parameters	***Severity***	***Spatial scale***	***Duration***	***Probability***	***Significance***
Impact 1	**Changes to hydrological regime**				
Pre- Mitigation	Moderate (3)	Local (3)	Permanent (6)	Likely (5)	Medium-Low (55)
Post- Mitigation	Minor (2)	Local (2)	Permanent (6)	Probable (4)	Medium-Low (36)

Issue 1	**Risk of subsidence**				
Impact 2	**Loss of ecological services**				
Pre- Mitigation	Moderate (3)	Local (2)	Permanent (6)	Probably (4)	Medium-Low (44)
Post- Mitigation	Moderate (3)	Local (2)	Permanent (6)	Probably (4)	Medium-Low (44)

9.1.2.3. Proposed mitigation

- No mining infrastructure with the exception of the TSF options is anticipated to impact on the wetland systems, and in light of the proposed mining operation, a 100m buffer zone should be adhered to for all mining development in the project area.
- The preferred TSF option is Site 2. This location is not directly associated with floodplain system, nor is the location associated with the nature reserve. Owing to the nature of the catchment proposed for Site 2, contaminants and impacts could be effectively mitigated and managed.
- The geotechnical stability assessment submitted by the rock engineer provides exact recommended specifications for stoping methodology. These should be strictly adhered to in order to prevent potential subsidence.

10. DISCUSSION

Two types of systems were identified for the project area, namely the Mogalakwena River floodplain and the Rooisloot, Ngwaditse and Dithokeng rivers. The Rooisloot, Ngwaditse and Dithokeng rivers are ephemeral systems and were predominantly dry during the field survey period. Water was noted in the lower reaches of the Rooisloot and Ngwaditse rivers and it was concluded that this is largely attributed to household effluent. No water was noted in the upper catchment areas of these systems, supporting this conclusion. As a result of this, an ecological state assessment of these systems could not be conducted. In spite of this, the riparian areas of these systems were delineated in order to determine the extent of these systems. These ephemeral systems are considered to primarily be conduits for the upper catchment reaches. The surrounding land uses have imposed pressures on these systems which has encouraged further erosion of the systems. The current land-uses and development of the area has altered the hydrological regime for the Rooisloot, Ngwaditse and Dithokeng Rivers, resulting in drainage networks being altered and excessive erosion of these systems. Evidence of impacts and the resulting affects from the altered hydrological regime is presented in Figure 10-1.

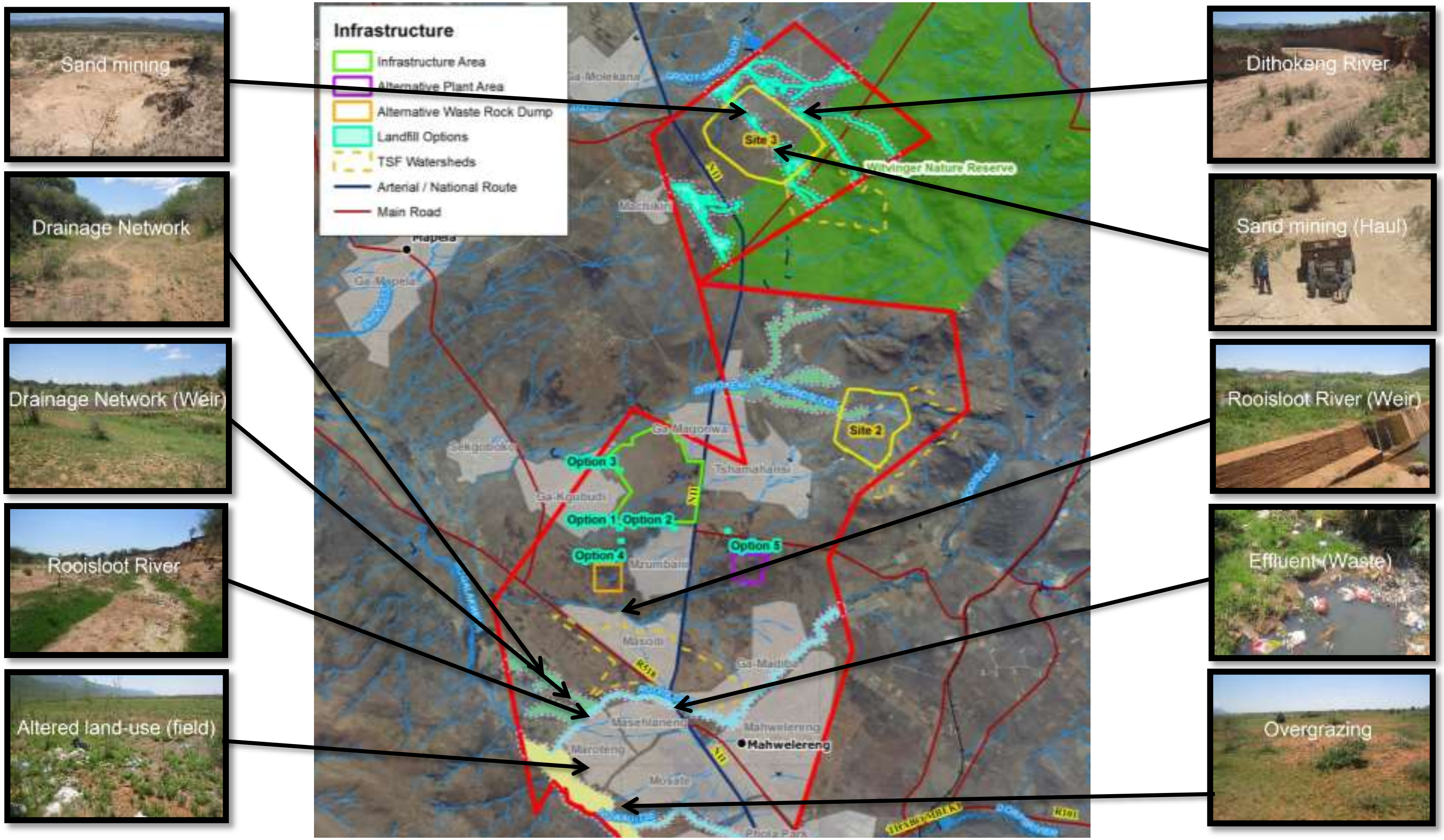

Figure 10-1: Identified impacts and the resulting affects to the hydrological regime for the study area

The Mogalakwena River floodplain provides a variety of ecological services varying from intermediate to high importance. The services identified to be of a high importance pertain largely to direct benefits of the local communities, such as water uses and food resources. In addition to this, the floodplain also contributes considerably to the maintenance of biodiversity. The floodplain system provides additional services of considerable importance which contribute to the enhancement of water quality for the catchment. This is important to note, considering the dependence of local communities on the system as a resource for water and food. Additionally the considerable nutrient input into the system from household effluent is a concern which needs to be managed. The overall health of the system was determined to be moderately modified and the system is expected to remain stable in this state for the next five years. The current land-uses, with particular reference to agricultural, sand mining and development have impacted on the integrity of the system.

The mining method to be employed for the Platreef Underground Mine is the sublevel blast hole stoping which, along with any of the shafts or surface infrastructure, with the exception of the TSF, it is not anticipated to impact on any of the wetlands. A geotechnical investigation could support this conclusion pertaining to the proposed mining operation having minimal, (if any), effect on the wetland systems. Owing to these factors, no direct impacts on the wetlands are expected due to habitat loss.

The risk of subsidence is the greatest potential threat to wetlands identified for the Platreef Underground Mine. As a consequence of this, flow patterns will be altered from their natural state. It has been recommended that the geotechnical stability assessment submitted provide exact recommended specifications for stoping methodology. These should be strictly adhered to in order to prevent potential subsidence.

11. RECOMMENDATIONS

The proposed activities are for underground mining and none of the surface infrastructure, with the exception of the proposed TSF options, coinciding with wetland areas. The largest risk is posed by the proposed sublevel blast hole stoping methodology, it is recommended that the geotechnical investigation be considered in order to mitigate any potential impacts, most notably subsidence. The preferred location for the TSF is Site 2. All mining infrastructure should adhere to a 100m buffer zone from all wetland areas.

12. REFERENCES

BIRKHEAD, A.L., JAMES, C.S. & KLEYNHANS, M.T. (2006). Hydrological and hydraulic modelling of the Nyl River floodplain Part 2: Modelling hydraulic behaviour. ISSN 0378-4738 Water SA Vol. 33 No. 1 January 2007.

DWAF, (2005). A practical field procedure for identification and delineation of wetlands and riparian areas. Department of Water Affairs and Forestry, Pretoria.

DWAF (2007). Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types by M. Rountree (ed); C.P. Todd, C. J. Kleynhans, A. L. Batchelor, M. D. Louw, D. Kotze, D. Walters, S. Schroeder, P. Illgner, M. Uys. and G.C. Marneweck. Report no. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

HIGGINS, S.I., COETZEE, M.A.S., MARNEWECK, C.G. & ROGERS, K.H. (1996) The Nyl River floodplain, South Africa, as a functional unit of the landscape: A review of current information. Afr. Jour. Ecol. 34 131-145.

IVERSEN, T.M., MADSEN, B.L. & BOGESTRAND, J. (2000). River conservation in the European Community, including Scandinavia. In: “Global Perspectives on River Conservation: Science Policy and Practice", Edited by P.J. Boon, B.R. Davies and G.E. Petts, John Wiley & Sons Ltd.

KLEYNHANS, C.J (1996) A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa). Journal of Aquatic Ecosystem Health 5: 1-14.

KLEYNHANS, C.J. (1999). The development of a fish index to assess the biological integrity of South African rivers. Water SA 25 (3): 265-278.

KLEYNHANS, C.J. (2000) Desktop estimates of the ecological importance and sensitivity categories (EISC), default ecological management classes (DEMC), present ecological status categories (PESC), present attainable ecological management classes (present AEMC), and best attainable ecological management class (best AEMC) for quaternary catchments in South Africa. DWAF Report, DWAF, Pretoria, South Africa.

KLEYNHANS, C.J. & LOUW, M.D. (2007). Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report.

KOTZE, D.C. & MARNEWECK, G.C. (1999). Guidelines for delineating the boundaries of a wetland and the zones within a wetland in terms of South African Water Act. As part of the development of a protocol for determining the Ecological Reserve for Wetlands in terms of the Water Act Resource Protection and Assessment Policy Implementation Process. Department of Water Affairs and Forestry, South Africa.

KOTZE, D.C., MARNEWECK, G.C., BATCHELOR, A.L., LINDLEY, D.C., & COLLINS, N.B. (2004). A Rapid assessment procedure for describing wetland benefits. Mondi Wetland Project.

KOTZE, D.C., MARNEWECK, G.C., BATCHELOR, A.L., LINDLEY, D.C., and COLLINS, N.B. (2007). A Technique for rapidly assessing ecosystem services supplied by wetlands. Mondi Wetland Project.

MACFARLANE, D.M., KOTZE, D.C., ELLERY, W.N., WALTERS, D., KOOPMAN, V., GOODMAN, P. & GOGE, C. (2009). A technique for rapidly assessing wetland health: WET-Health. WRC Report TT 340/08.

MARNEWECK, G.C. & BATCHELOR, A.L. (2002). Wetland inventory and classification. In Palmer, R.W., Turpie, J., Marneweck, G.C. and Batchelor, A.L. (Eds). Ecological and Economic Evaluation of Wetlands in the Upper Olifants River Catchment. Water Research Commission Report No K5/1162.

MCCARTNEY, M.P. (2000). The influence of a headwater wetland on downstream river flows in sub-Saharan Africa. In: Land-Water Linkages in Rural Watersheds Electronic Workshop. 18 September – 27 Ocober. Food and Agriculture Organization of the United Nations, Rome, Italy.

ROBERTSON, M.P., VILLET, M.H. & PALMER, A.R. (2004). A fuzzy classification technique for predicting species' distributions: applications using invasive alien plants and indigenous insects. Diversity and Distributions 10: 461–474.

VAN WYK, E., BREEN, C.M., ROUX, D.J. ROGERS, K.H., SHERWILL, T. & VAN WILGEN, B.W. (2006). The Ecological Reserve: Towards a common understanding for river management in South Africa. Water SA 32(3): 403 -409.

Appendix A: A curriculum vitae

ANDREW HUSTED

Mr. Andrew Husted

Ecologist/GIS Specialist

Biophysical Department

Digby Wells Environmental

Pri. Sci. Nat. (400213/11)

1 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)

2 EMPLOYMENT

- August 2007 – Present: Digby Wells Environmental, as an aquatic ecologist
- January 2006 – June 2007: Econ@UJ, as an aquatic ecologist

3 EXPERIENCE

Andrew is the manager of the biophysical department which consists of the ecological and rehabilitation units. He is responsible for the management and co-ordination of the relevant specialists in order to fulfil the departmental and company objectives as well as to oversee implementation of the required strategies. Additional managerial responsibilities include the preparation of project proposals for a variety of specialist studies, general project management as well as office administration. He also provides input into specialist reporting as well as conducts reviews of the relevant studies. Andrew is an aquatic ecologist and has obtained a wealth of experience due to the exposure to a variety of projects, within different systems throughout Africa and in selected parts of Europe.

3.1 Aquatic ecology

The River Health Programme (RHP) is a national programme in which Andrew has had extensive training on both a provincial and national level. He is a registered and recognised user of the programme. In addition to this, he has been involved in the formulation of the programme on an on-going basis. Through this, he has a good understanding of the benefits and uses of such a programme, as well as the limitations offered by it. Andrew is also an accredited South African Scoring System version 5 (SASS5) practitioner, a requirement of the RHP. Experience for this study area includes the following:

- Aquatic state assessments: Ghana, Mali, DRC, Botswana, Ivory Coast, Sierra Leone, Armenia and South Africa
- Biomonitoring assessments: DRC and South Africa
- Fish community state assessments; Botswana and South Africa
- Instream flow requirements: DRC

3.2 Aquatic hydropower assessments

Owing to the growing demand to find alternative energy sources, Andrew has been exposed to hydropower generation projects as a result. These studies assess the potential of the project to affect the structure and function of the surface aquatic ecosystems. These include the reduction in flows below the abstraction point, and the establishment of a barrier that may affect the access of species to the upper reaches of the system. Local fish communities are used as indicators of ecological health to evaluate the potential effects of reduced flows and the establishment of a barrier in the system. A habitat type modelling approach with additional information obtained from hydraulic modelling is used to assess the response of fish communities to changes in habitat types due to a reduction in flows. Information collated from these sources is then used to prescribe the instream flow requirements for the system. Experience for this study area includes the following:

- Instream flow requirements: DRC

3.3 Wetland assessments

Andrew was part of the first group of consultants to be trained by the Department of Water Affairs and Forestry (DWAF) during a yearlong training programme (2008). Due to this training, he is recognised by the Mondi Wetlands Programme as a competent wetland delineator. The programme not only allowed for wetland areas to be delineated but also for ecological services offered by the wetlands to be identified and described as well as for the integrity (health) of the wetland units to be assessed. Andrew also received a certificate of competence from Rhodes University for tools which are considered for wetland delineations as well as the WET-Management series. Owing to complexity of wetlands and the demands and stresses placed on these systems, he was trained in the soil classification of wetlands as well as the rehabilitation methods and techniques widely adopted to better understand this specialist area. Experience for this study area includes the following:

- Wetland delineations: Senegal, Sierra Leone and South Africa
- Riparian delineations: Botswana and South Africa
- Wetland functional assessments: Botswana, Senegal, Sierra Leone and South Africa
- Wetland integrity assessments: Botswana, Senegal, Sierra Leone and South Africa
- Wetland offset strategy: South Africa
- Wetland rehabilitation: South Africa

3.4 Toxicity and metal analysis

Andrew completed a master’s degree in the bioaccumulation of selected metals in selected fish populations in South Africa. Owing to the growing need to assess and monitor the state of the available water resources, Andrew also developed an interest in toxicity testing. The results for the respective components are compared to the relevant guidelines and management measures prescribed accordingly. In addition to these two components, Andrew has also analysed for metals in sediment samples. Experience for this study area includes the following:

- Toxicity: Ghana, Mali, Armenia and South Africa
- Metal analysis: DRC, Ghana, Mali, Armenia and South Africa
- Sediment analysis: Ghana, Mali and South Africa

3.5 Telemetry

Andrew has obtained training and experience with the application of telemetry to Tigerfish (*Hydrocynus vittatus*) both in Botswana and the Limpopo province of South Africa. This included the capture of the species, as well as the sedation, transport, tagging and stocking of the species into a different system. In addition to this, the training required the monitoring of tagged individuals throughout the year which included 24 hour surveys. The aim of such a component was to conduct an assessment of the behaviour of the tagged populations. Andrew was co-author for a paper submitted on this project to the African Journal of Aquatic Sciences. Experience for this study area includes the following:

- Fish telemetry: Botswana and South Africa

4 PROFESSIONAL REGISTRATION

South African Council for Natural Scientific Professions: 400213/11

5 TRAINING

- Wetland and Riparian Delineation Course for Consultants (Certificate of Competence) – DWAF
- The threats and impacts posed on wetlands by infrastructure and development: Mitigation and rehabilitation thereof – Gauteng Wetland Forum
- Ecological State Assessment of Lentic Systems using Fish Population Dynamics – University of Johannesburg/Rivers of Life
- Soil Classification and Wetland Delineation – Terra Soil Science
- Wetland Rehabilitation Methods and Techniques - Gauteng Wetland Forum
- Application of the Fish Response Assessment Index (FRAI) and Macroinvertebrate Response Assessment Index (MIRAI) for the River Health Programme
- Tools for a Wetland Assessment (Certificate of Competence) – Rhodes University

6 PRESENTATIONS

- Zoology postgraduate colloquiums 2005, 2006 and 2007.
- Department of Water Affairs and Forestry (Bronkhorstspruit). Findings of a wetland assessment and aquatic assessment conducted for a project for Xstrata Coal South Africa, November 2008.
- Department of Water Affairs and Forestry (Pretoria). Findings of two case studies conducted for accreditation and recognition by DWAF as a competent wetland specialist, November 2008.

- Harress Pickel Consult AG (Selebi Phikwe, Botswana). Environmental study to establish the baseline biological and physical conditions of the Letsibogo Dam near Selebi Phikwe, Botswana. (Programme “Economic Diversification of the Mining Sector”, 8 ACP BT 13). October 2009.
- Xstrata Coal South Africa (Oogies). Formulation of a Biodiversity and Land Management Plan, November 2009, April 2010.
- Exxaro Coal Pty (Ltd) (Belfast area). EIA Feedback meeting for the Public Participation Process. Findings of the integrated wetland assessment and the formulated wetland offset strategy for the project, April 2010
- BHP Biliton Energy Coal South Africa (Johannesburg). Findings of the aquatic assessments and wetland assessments conducted for the respective project area, May 2010.
- Xstrata Coal South Africa (Oogies). Submission of a Biodiversity and Land Management Plan, July 2010.
- The International Society of Limnology conference (Cape Town). Use of bio-telemtry to evaluate the advantages and disadvantages of using Tigerfish (*Hydrocynis vittatus*) as a management option for the control of alien species in souther African impoundments. Case study: Letsibogo Dam, Botswana, August 2010.
- The International Association of Impact Assessments South Africa conference (Pretoria). The management of biodiversity in areas associated with mining through the application of a GIS based, integrated Biodiversity Land Management Plan (BLMP), August 2010.

7 PUBLICATIONS

Husted, A. (2009). Aspects of the the biology of the Bushveld Smallscale Yellowfish (*Labeobarbus polylepis*): Feeding biology and metal bioaccumulation in five populations.

O’Brien, G.C., Bulfin, J.B., Husted, A. and Smit, N.J. (2012). Comparative behavioural assessment of an established and new Tigerfish (*Hydrocynus vittatus*) population in two manmade lakes in the Limpopo catchment, southern Africa. (for review)

In an endeavour to continue to improve my skills and specialist knowledge of my areas of interest, continuous training is required. Also considering the environment we live in today and demand for goods and services from our natural systems, there is a growing need to better understand our ecosystems so that we can better manage these systems for future generations.

Appendix B: Methodology

Floodplain delineation

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

Terrain Unit Indicator

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

Soil Form Indicator

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

Soil Wetness Indicator

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

Vegetation Indicator

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

<u>Riparian delineation</u>

Topography associated with the watercourse

A good rough indicator of the outer edge of the riparian areas is the edge of the macro channel bank. This is defined as the outer bank of a compound channel (see figure 5), and should not be confused with the active river or stream channel bank. Flood benches may exist between the active channel and the macro channel bank, and are often covered by alluvial deposits and may have riparian vegetation on them. The macro channel bank often represents a dramatic change in the frequency, duration and depth of flooding experienced, leading to a corresponding change in vegetation structure and composition.

Vegetation

Unlike the delineation of wetland areas, where hydromorphic soils are the primary indicator, the delineation of riparian areas relies primarily on vegetative indicators. Using vegetation, the outer boundary of a riparian area must be adjacent to a watercourse and can be defined as the zone where a distinctive change occurs:

- in species composition relative to the adjacent terrestrial area; and

- in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

These differences between riparian and terrestrial vegetation are primarily a result of more water being available to species growing adjacent to watercourses than to those growing further away. It is therefore not necessary to identify species in order to delineate the riparian boundary. All that is needed is to compare relative changes in species composition and growth forms. Where an area has been transformed, or in the absence of natural vegetation, alluvial soils and deposited material will serve as the primary indicators.

Alluvial soils and deposited material

Alluvial soils can be defined as relatively recent deposits of sand, mud, etc set down by flowing water, especially in the valleys of large rivers. Riparian areas often, but not always, have alluvial soils. Whilst the presence of alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas, it can be used to confirm the topographical and vegetative indicators.

Deposited material can also be used to delineate the areas where bank stabilisation, provided by the roots of riparian vegetation, is most important. This material may be deposited adjacent to the macro-channel bank during flooding, and can include vegetation debris as well as soil deposits.