Appendix D5

Wetland Impact Assessment Report for the Proposed Mine Waste Solutions (MWS) Kareerand Tailings Storage Facility (TSF) Extension Project

-De Castro and Brits, 2018

Wetland Impact Assessment Report for the Proposed Mine Waste Solutions (MWS) Kareerand Tailings Storage Facility (TSF) Extension Project (Stilfontein, North West Province)

Report Version 6
March 2018

January 2018

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Registered with the South African Counsel for Natural Scientific Professionals
(Registration number: 400097/09)

Specialist reports and reports on specialist processes - Checklist		
	NEMA Regs (2014) - Appendix 6	**Reference to section of specialist report or justification for not meeting requirement**
1	A specialist report or a report on a specialised process prepared in terms of these Regulations must contain -	
(a) i	the person who prepared the report; and	Title page
(a) ii	the expertise of that person to carry out the specialist study or specialised process;	Appendix A
(b)	a declaration that the person is independent in a form as may be specified by the competent authority;	Page iii
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Page 1, 4 and 5
(d)	the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Page 11 and 60
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process;	Page 6 - 11
(f)	the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Page 24 - 36
(g)	an identification of any areas to be avoided, including buffers;	Page 34 and 39
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Page 38
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Page 5 and 11
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment;	Page 14 - 48
(k)	any mitigation measures for inclusion in the EMPr	Page 40 - 49
(l)	any conditions for inclusion in the environmental authorisation	Page 40 - 76
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation	Page 40 - 60
(n)	a reasoned opinion -	
.i	as to whether the proposed activity or portions thereof should be authorised and	Page 73 – 74

.ii	if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	
(o)	a description of any consultation process that was undertaken during the course of carrying out the study;	-
(p)	a summary and copies if any comments that were received during any consultation process, and -	-
(q)	any other information requested by the competent authority.	-

DECLARATION

I, Lourens Erasmus Retief Grobler, declare that I –

- act as an independent specialist consultant in the fields of botanical and ecological science;
- 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;
- have and will not have any 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 material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report; and
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.

LOURENS ERASMUS RETIEF GROBLER

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LIST OF ACRONYMS

Acronym	Explanation
AGA	Anglo Gold Ashanti
DEA	Department of Environmental Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation (previously referred to as the Department of Water Affairs and Forestry)
EC	Ecological Category
EI	Ecological Importance
EIS	Ecological Importance and Sensitivity
ES	Ecological Sensitivity
GA	General Authorisation
HGM	Hydro-geomorphic unit
MWS	Mine Waste Solutions
NFEPA	National Freshwater Ecosystem Priority Areas
NWDREAD	North West Department of Rural Environmental and Agricultural Development
NWBSP	North West Biodiversity Sector Plan
PES	Present Ecological State
TSF	Tailings Storage Facility
WMA	Water Management Area
WUL	Water Use License
WULA	Water Use License Application

GLOSSARY OF TERMS

Term	Explanation
Catchment	A drainage basin or land area with convergent contour lines where water flow starts and accumulate to form a drainage network. Also referred to as a watershed (specifically in the US), but a watershed can also refer to a catchment divide
Catchment divide	Divisions between catchments, located on areas with divergent contour lines.
Channelled valley bottom wetland (HGM unit)	A valley bottom wetland with a river channel running through it. Channelled valley bottom wetlands are characterised by their position on valley floors and the absence of characteristic floodplain features. Dominant water inputs to these wetlands are from the river channel flowing through the wetland either as surface flow resulting from flooding or as subsurface flow, and/or from adjacent valley side slopes (as overland flow or interflow), (Ollis *et al*. 2013).
Depression wetland (HGM unit)	An inland aquatic ecosystem with closed (or near-closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates Dominant water sources are precipitation, groundwater discharge, interflow and diffuse (or concentrated) overland flow. Dominant hydrodynamics are primarily seasonal with resultant vertical fluctuations (Ollis *et al*., 2013).
Floodplain wetland (HGM unit)	A wetland area within a floodplain Water and sediment input to these wetlands is mainly via overspill from a river channel during flooding. Floodplains consists of gently sloping land adjacent to, and formed by, an alluvial river channel (Ollis *et al*., 2013).
Headcut	An erosion feature that can develop within a channel, at the proximal end of a channel, or on an unchannelled slope. They are the precursors to channel development as headcut migration create or extent channels.
Hillslope seep wetland (HGM unit)	See seep wetland
Hydro-geomorphic	A type of aquatic ecosystem distinguished primarily on the basis of landform (shape and setting), hydrological characteristics (nature of water movement), and hydrodynamics (direction and strength of water movement), (Ollis *et al*., 2013).
Hydromorphic soil	Soils with features that have developed under anaerobic conditions due to a fluctuating water table or sufficient periods of saturation
Hydrophyte	Plant species that are adapted to wetter areas and can therefore grow in water or soils that are at least periodically saturated and/or inundated. Can also refer to facultative and obligate hydrophyte species to help indicate the gradient of wetness to which a particular species is adapted.
Instream habitat	Includes the physical structure of a watercourse and the associated vegetation in relation to the bed of the watercourse (National Water Act, Act No. 36 of 1998), (NWA)
Pan wetland	See depression wetland.
Riparian habitat/zone/area	The physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized 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 (NWA).

Term	Explanation
River	A linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water. A river includes both the active channel and the riparian zone (Ollis *et al*., 2013)
Seep wetland (HGM unit)	Wetland area located on gently to steeply sloping land and dominated by the colluvial (i.e. gravity-driven), unidirectional movement of water and material down-slope. Seeps are often located on the side-slopes of a valley, but they do not typically, extend unto a valley floor. Water inputs are primarily via subsurface flows from an up-slope direction.
Unchannelled valley bottom wetland (HGM unit)	A valley bottom wetland without a river channel running through it. These wetlands are characterised by the location on valley floors, an absence of distinct channel banks, and the prevalence of diffuse flows. Water inputs are typically from an upstream channel and seepage from adjacent valley side slopes, if present.
Watercourse	Watercourse definitions as provided in the NWA: • A river or spring; • A natural channel in which water flows regularly or intermittently; • A wetland, lake or dam into which, or from which, water flows and • Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse. A reference to a watercourse includes, where relevant, its bed and banks.
Wetland	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 (NWA).
Wetland flat (HGM unit)	A level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or bench. Closed elevation contours are not evident around the edge of a wetland flat. They are characterised by the dominance of vertical water movements associated with precipitation, groundwater inflow, infiltration and evaporation. Horizontal water movements within these wetlands, if present, are multi-directional, due to the lack of any significant change in gradient within the wetland (Ollis *et al*., 2013).

1. INTRODUCTION AND PROJECT DESCRIPTION

1.1 Background and Project Description

Imperata Consulting CC was subcontracted by De Castro and Brits Ecological Consultants CC to conduct a baseline wetland delineation and assessment study for the proposed extension of the existing Kareerand Tailings Storage Facility (TSF), southeast of Stilfontein in North West Province. This wetland study forms part of an environmental authorisation process that will incorporate several different specialist studies. This study area forms part of AngloGold Ashanti's (AGA) Mine Waste Solutions (MWS) property.

Mine Waste Solutions (MWS) is a tailing dam reclamation operation situated in the North West Province of RSA, with tailings dams in the Klerksdorp, Orkney, Stilfontein and Hartbeesfontein area that are being processed. MWS is a subsidiary of AngloGold Ashanti (AGA). Currently tailings from the MWS plant are sent to the Kareerand TSF. The capacity of the Kareerand TSF will begin to become a constraint on the tailing reclamation operation from the beginning of 2021. In order to keep within the designed rate of rise the tonnage deposited on the TSF will need to be reduced. In order to maintain operations, it is required to bring further TSF capacity into operation by the beginning of 2021.

MWS has identified that the optimum strategy for creating additional TSF capacity is to construct an extension of the existing 564 ha Kareerand TSF whilst at the same time increasing the final design height of the existing footprint. These activities will form part of the Kareerand TFS Extension Project. The extension is proposed to be constructed to the north-west of the existing TSF footprint and the extension footprint will be approximately 382.6 ha in extent and will abut onto the existing footprint (Figure 1). Due to the increase surface area of the extended TSF there will be additional return water dams (Figure 1) to control run off from the extended TSF. Potential borrow areas (borrow pits) for extraction of soils for use in stabilising the retaining walls of the TSF extension are also included in this project (see Figure 1).

The study area boundary, illustrated in Figure 1, was demarcated around the infrastructure footprints by the ecologist working on the project, Mr Antonio de Castro from De Castro and Brits Ecological Consultants. This was done as a practical means to investigate a larger area than just the proposed infrastructure footprints in order to determine the sensitivity of the surrounding area. Sensitivity mapping of a larger area can aid impact mitigation by making recommendations to change the proposed infrastructure layout where it overlaps with sensitive areas.

The following proposed infrastructure features were evaluated within the demarcated study area (Figure 1):

- TSF Extension - The proposed combined size of the extended Kareerand TSF will then be 946.6 ha, of which 382.6 ha will be added onto the exiting footprint and extend into the study area.
- Burrow pits - Three separate burrow pits with a combined surface area of 666.3 ha.
- Return water dams – Four return water dams with a combined size of 43.2 ha.

This report deals with potential impacts of selected new mining infrastructure features on wetland watercourses present in the proposed footprint areas, the study area and in the surrounding 500 m study area buffer (the latter at a desktop scale only). The site visit for this study was conducted in November 2017.

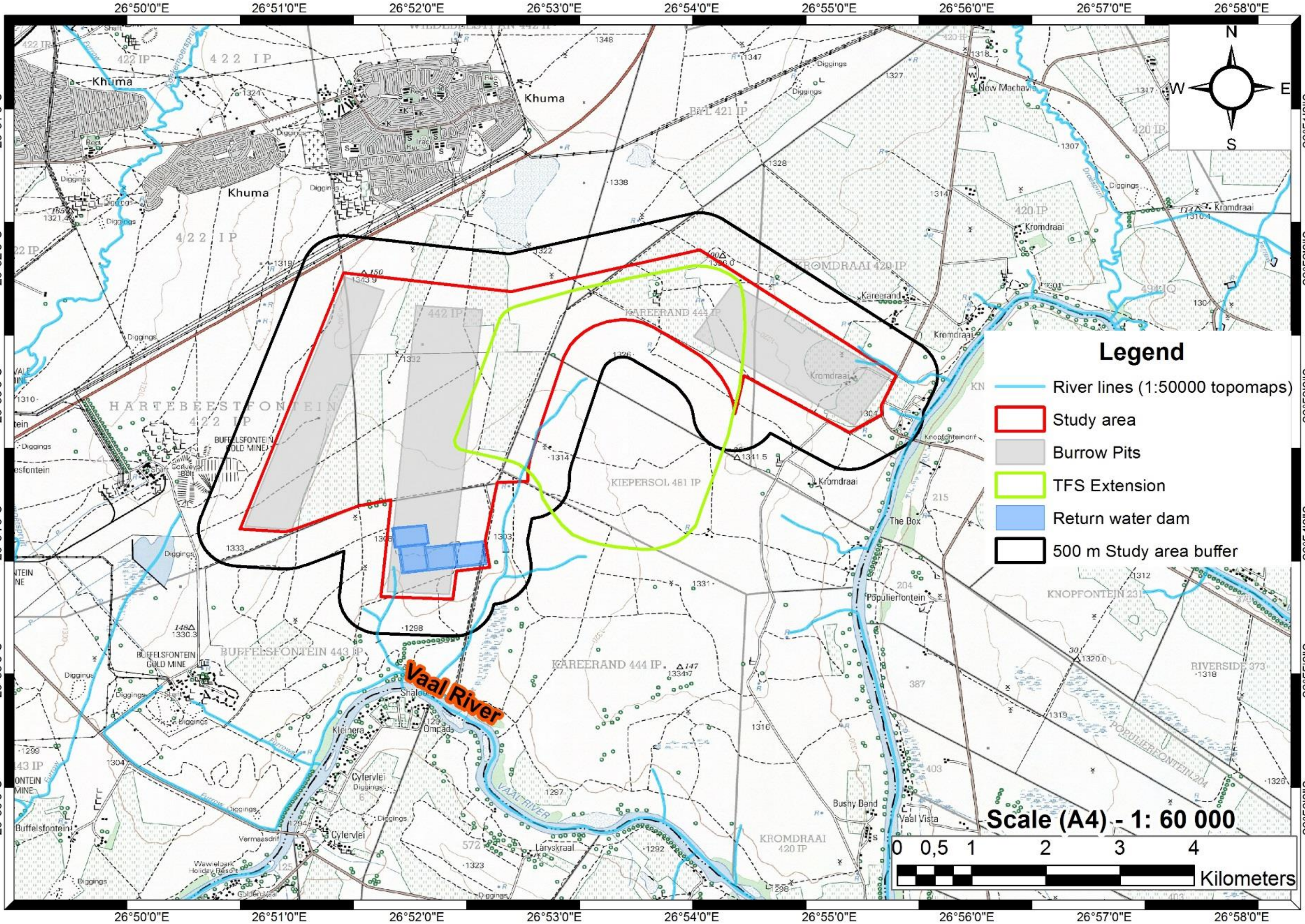

Figure 1: Illustrates the assessed study area consisting of different proposed footprint components along with a surrounding 500m study area buffer and drainage lines from the 1:50000 topographical map 2626DD (Stilfontein).

1.2 Overview of Wetlands and Riparian Habitat

In terms of the Ramsar Convention on Wetlands (Iran 1971), to which South Africa is a contracting party, "… wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, and sea grass beds, but also coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs" (Ramsar Convention Secretariat 2007).

In South Africa, wetlands are defined 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" (National Water Act, 1998 (Act No. 36 of 1998)). Wetlands are also included in the definition of a watercourse within the NWA, which implies that whatever legislation refers to the aforementioned will also be applicable to wetlands.

In addition, the NWA stipulates that "…reference to a watercourse includes, where relevant, its bed and banks…". This has important implications for the management of watercourses and encroachment on their boundaries, as discussed further on in this document.
The NWA defines riparian areas as "…the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized 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…" Note that this does not imply that the plant species within a riparian zone must be aquatic, only that the species composition of plant assemblages must be different within the riparian area and adjacent uplands.

In terms of the wetland delineation document available from the Department of Water Affairs and Forestry (DWAF), now known as the Department of Water and Sanitation (DWS), "wetlands must have one or more of the following attributes" (DWAF, 2005):

- Wetland soils (hydromorphic) that display characteristics resulting from prolonged saturation.
- The presence, at least occasionally, of hydrophytes (wetland plants).
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50 cm of the soil.

It follows that the level of confidence associated with a specific area being considered as a wetland is proportionate to the number of confirmed indicators that positively correlate with wetland habitat. Not all indicators are always present within a specific biophysical and land use setting, while not all indicators are always reliable and/or useful under all conditions. The delineation of wetlands can therefore be challenging in disturbed environments, such as mining and urban settings, where disturbances to the natural soil and vegetation are common.

1.3 Details of the Author

Retief Grobler has undergrad majors in Botany (UP) and Soil Science (UP), an honours degree in Botany from the University of Pretoria (cum laude), and an MSc (cum laude) in Botany from the Department of Plant Sciences (UP) with a focus on peatland wetland systems. He is a registered Pr. Sci. Nat professional natural scientist in the fields of Botanical Science and Ecological Science (Reg. no. 400097/09), and has been working as a watercourse specialist consultant based in Gauteng over the last 12 years. He has wetland and related watercourse specialist consulting work experience in Gauteng, Mpumalanga, North-West, Limpopo, Northern Cape, Free State, Eastern Cape and KwaZulu-Natal Provinces, as well as outside of South Africa in Mozambique. Areas of specialisation include the delineation, description and assessment of watercourses, including wetlands, riparian habitats, and headwater drainage lines. A CV is provided in Appendix A.

2. TERMS OF REFERENCE

2.1 General

Terms of references associated with the specialist watercourse investigation include the following for the study area as defined in Section 1 (Figure 1):

- Desktop analyses and literature review of existing wetland-related information, including available recent and historic aerial imagery.
- A field survey by a Pr.Sci.Nat. registered ecologist that will investigate, delineate and describe wetlands according to the field procedure developed by the DWS (DWAF 2005; DWAF 2008).
- A classification of identified wetland areas into appropiate hydro-geomorphic units according to the National Wetland Classification System for South Africa (Ollis et al., 2013).
- Description of identified wetland and related watercourse indicators; these include soil, plant, and terrain indicators, as well as others published in literature (e.g. Nobel *et al.*, 2005).
- Assessments of the Present Ecological State (PES) and the Ecological Importance and Sensitivity (EIS) of delineated wetlands according to the applicable methods developed by either the Department of Water and Sanitation (DWS) or the Water Research Commission (WRC), (DWAF 1999; DWAF 2007; Macfarlane *et al.*, 2008; Rountree & Malan 2013). The accuracy and level of confidence of these assessments will be improved through a wet season survey (approximately November to May) rather than a dry season survey.
- Assessment of ecosystem services associated with identified wetlands will also be determined with the EIS method described by Rountree and Malan (2013).
- Surrounding wetland areas located in a 500m radius around the proposed footprints will be delineated at a secondary level of detail through limited site sampling and a stronger desktop approach (Figure 1). Wetlands located within a 500 m radius around proposed Section 21 (*c*) and (*i*) water uses form part of the regulated area for which authorisation have to be obtained from the DWS, either as a General Authorisation (GA) or a full Water Use License (WUL), (DWAF, 2009).
- Creation of wetland sensitivity maps and associated GIS shapefiles.
- Undertaking a Risk assessment protocol with associated matrix for expected project-related impacts that may affect identified wetland systems, based on the impact

assessment method published in GN 509 (published 26 August 2016).

- Provision of recommended impact mitigation measures related to the proposed development. This includes the recommendation of site specific wetland buffers that take into consideration the guideline document for the determination of wetland buffer zones (Macfarlane *et al.* 2015).
- Performing a risk assessment protocol with associated matrix for expected project-related Section 21 (c) and (i) water uses that may affect identified wetland systems. The risk matrix assessment will be based on the method published in GN 509 (26 August 2016), as well as available information regarding proposed mining activities and infrastructure.
- All of the above incorporated into a single report.

2.2 Assumptions & Exclusions

Assumptions and exclusions associated with this study include the following:

- Project proponents will always strive to avoid and mitigate potentially negative project related impacts on the environment, with impact avoidance being considered the most successful approach, followed by mitigation. It further assumes that the project proponents will seek to enhance potential positive impacts on the environment.
- Spatial GIS shapefiles received from the client that demarcate the proposed infrastructure development footprints are accurate.
- The project proponents will commission an additional study to assess the impact(s) in the event that there is a change in the size and/or extent of the study area or proposed infrastructure that is likely to have a potentially highly significant and/ or unavoidable impact on delineated wetlands.
- The delineation and aquatic ecological assessment of the nearby Vaal River does not form part of this study. An Aquatic Fauna Impact Assessment study has been undertaken by Dr Pieter Kotze from Clean Stream Biological Services as part of the environmental authorisation process for the proposed project (Kotze 2017).

3. METHODOLOGY

3.1. Methods and Approach

The following methods and approach were applied as part of the wetland investigation:

- Existing spatial datasets that indicate potential watercourses and ecologically important areas were used as part of an initial desktop approach. These include the following:
    - The 1:50 000 river line dataset of the study area and its surroundings was used, as illustrated on the relevant topographic map (2626DD Stilfontein).
    - The National Freshwater Ecosystem Priority Areas (NFEPA) spatial dataset was used to help identify potential wetland areas within the study area and its immediate surroundings. This wetland layer has been formed by combing information from the National Land Cover 2000 data set (NLC 2000), 1:50 000 topographic maps and sub national data (Van Deventer *et al.* 2010).
    - The 2013-14 South African National Land Cover dataset, which indicates wetlands, permanent water and seasonal water based on the globally available Landsat 8 imagery (GTI, 2015). This dataset was used to further help identify the presence of wetlands and other watercourses within the study area. The dataset was downloaded from the Maps and Graphics section of the Department of Environmental Affairs (DEA), (GTI, 2015).
    - Spatial data sets that indicate Critical Biodiversity Areas in the North West Biodiversity Sector Plan (NWBSP) was obtained in February 2016 from Mr. Ray Schaller (NWREAD, 2015), via De Castro and Brits Ecological Consultants. Mr. Schaller is the Conservation Planner at the North West Department Rural, Environment and Agricultural Development (NWREAD).
    - A historical aerial photograph from 1939 was obtained for the study area and georeferenced for wetland interpretation and mapping purposes.
- Watercourses were identified and delineated within the study area through the procedure described by the Department of Water and Sanitation (DWS; previously also known as DWAF and DWA), (DWAF 2005 & DWAF, 2008).
- Available wetland indicators that were investigated included hydromorphic (wetland soil) features, the presence of wetland plant species (e.g. hydrophytes), presence of riparian species and vegetation features, alluvial soil features, and terrain unit indicators.
- Investigated hydromorphic features typically included the presence of mottling, gleying, localised iron depletion, low chroma matrix colours, and organic enrichment in the A horizon (DWAF, 2008).
- Sample points were generally arranged along transects perpendicular to discernible flow paths, in order to record gradients of change between terrestrial and watercourse habitats.
- The field surveys primarily focussed on the delineation of watercourses within the study area, while selected areas were investigated within a 500 m radius of study area associated infrastructure features (Figure 1). The majority of suspected wetland areas within the 500m buffer area were mainly delineated and classified through a desktop approach with limited sampling.
- Identified wetland areas were delineated into GIS polygon shapefiles, which were used for map creation.
- All natural wetlands identified within the study area were classified according to the recently completed 'Classification System for Wetlands and other Aquatic Ecosystems in South Africa' up to the hydrogeomorphic (HGM) unit level (Ollis *et al*. 2013).

- The HGM classification system is based on three key parameters pertaining to the wetland: the geomorphic setting of the wetland, the source of water inputs into the wetland, and its hydrodynamics (how does water move through the wetland), (Brinson 1993; Kotze *et al*. 2008).
- The HGM classification system developed by Ollis *et al*. (2013) was slightly modified to refer to 'pan' wetlands rather than 'depression' wetlands due to the widespread vernacular use of the term 'pan' or 'pans'. The use of the term pan is also common in South African scientific literature to refer to endorheic wetland systems in the country [e.g. Kotze *et al*., (2008); Mucina & Rutherford (2006)].
- The Present Ecological State (PES) of seep, channelled and unchannelled valley bottom wetlands present within the study area and 500m study area buffer was assessed through a Level 1 WET-Health assessment (Macfarlane *et al.*, 2008), (Table 1).
- Recently developed PES assessment methods, such as the WET-Health technique, are not well suited for pan/depression HGM units, as the geomorphological component of these methods are not applicable to pans. Kleynhans (DWAF 1999) developed a method for determining, at the 'Intermediate level', the Present Ecological Status of palustrine wetlands according to a modified 'Habitat Integrity' approach. This simple, yet robust, method was used to determine the PES of delineated pan HGM units.
- The PES method compares the current condition of a wetland, or other watercourse type, to its perceived reference condition, in order to determine the extent to which the wetland had been modified from its pristine (reference) condition.
- Results from the PES assessments are rated into one of six categories ranging from unmodified/ pristine wetlands (Class A) to critically/ totally modified HGM wetland units (Class F), (Table 1).
- The A→F scale represents a continuum, and that the boundaries between categories are notional, artificially-defined points along the continuum. This situation can be described by the concept of a fuzzy boundary, where a particular entity may potentially have membership of both classes. For practical purposes, these situations are referred to as boundary categories and are denoted as B/C, D/E, etc. A similar approach can be applied to the determination of EIS categories
- An Ecological Importance and Sensitivity (EIS) assessment of identified natural wetland areas were undertaken to provide an indication of the conservation value and sensitivity of delineated wetlands. The applied EIS wetland assessment was based on the classes indicated in Table 2 and the following criteria (Rountree & Malan 2013):
    - Habitat uniqueness
    - Species of conservation concern
    - Habitat fragmentation with regards to ecological corridors
    - Prominent ecosystem services

Table 1: Description of A – F Present Ecological State (PES) categories for wetlands and rivers, ranging from “Natural” (Category A) to “Critically Modified” (Category F), (DWAF 1999; Macfarlane, *et al* 2008).

Category		Description	Combined impact score (Macfarlane *et al.*, 2008)	Score (%) (DWAF, 1999)
A	Natural	Unmodified, Natural.	0-0.9	>4
B	Largely Natural	Few modifications, small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	1-1.9	>3 and <=4
C	Moderately Modified	A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	2-3.9	>2.5 and <=3
D	Largely Modified	Large loss of natural habitat, biota and basic ecosystem functions has occurred.	4-5.9	<=2.5 and >1.5
E	Seriously Modified	The losses of natural habitat, biota and basic ecosystem functions are extensive.	6-7.9	>0 and <=1.5
F	Critically Modified	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	8-10	0

*: If any of the attributes are rated <2 as determined through the method developed by DWAF (1999), then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean.

Table 2: Indicates Ecological Importance and Sensnsitivity (EIS) categrories for wetlands (Rountree & Malan, 2013).

Ecological Importance and Sensitivity Category (EIS)	Range of Median	EIS Class
Very high: Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these watercourses 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.	4	**A**
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these watercourses may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>3 and <4	**B**
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these watercourses 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.	>2 and </=3	**C**
Low/Marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these watercourses is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>1 and </=2	**D**
None: Wetlands that are rarely sensitive to changes in water quality/hydrological regime.	0 and </=1	**E**

3.2. Impact Assessment Method

The DWS Risk assessment protocol that was used was obtained from GN 509. Risk posed to "resource quality", as defined in the NWA, must be scored according to the Risk Rating Table for Severity (Table 3). A Severity score is then generated. Consequence, Likelihood and finally Significance scores are automatically calculated with the rest of parameters according to respective Risk Rating Tables (Tables 3-10).

Risk is determined after considering all listed control /mitigation measures. Borderline LOW /MODERATE risk scores can be manually adapted downwards up to a maximum of 25 points (from a score of 80) subject to listing of additional mitigation measures considered and listed in RED font. ONLY LOW RISK ACTIVITIES located within the regulated area of the watercourse will qualify for a General Authorisation (GA) according to GN 509 (Table 10). Medium and High risk activities will require a Section 21 (c) and (i) water use licence. The risk rating is determined by combined scores from the following matrix components (Tables 3-10):

Consequence= Severity + Spatial Scale + Duration
Likelihood = Frequency of the Activity+ Frequency of the Impact + Legal Issues + Detection
Risk = Consequence x Likelihood

Table 3: Severity - How severe does the aspects impact on the resource quality (flow regime, water quality, geomorphology, biota, habitat)? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful and/or wetland(s) involved	5
Where "or wetland(s) are involved" it means that the activity is located within the delineated boundary of any wetland. The score of 5 is only compulsory for the significance rating.	

Table 4: Spatial scale - How big is the area that the aspect is impacting on? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional / neighbouring areas (downstream within quaternary catchment)	3
National (impacting beyond secondary catchment or provinces)	4
Global (impacting beyond SA boundary)	5

Table 5: Duration -How long does the aspect impact on the resource quality? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

One day to one month, PES, EIS and/or REC not impacted	1
One month to one year, PES, EIS and/or REC impacted but no change in status	2
One year to 10 years, PES, EIS and/or REC impacted to a lower status but can be improved over this period through mitigation	3
Life of the activity, PES, EIS and/or REC permanently lowered	4
More than life of the organisation/facility, PES and EIS scores, a E or F	5
PES and EIS (sensitivity) must be considered.	

Table 6: Frequency of the activity - How often do you do the specific activity? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5

Table 7: Frequency of the incident/impact - How often does the activity impact on the resource quality? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

Table 8: Legal issues - How is the activity governed by legislation? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

No legislation	1
Fully covered by legislation (wetlands are legally governed)	5
This is a constant, will always be regulated in terms of Section 21 water use, if not then the affected activity should not be subject to the Risk Matrix. **Located within the regulated areas refers to location within the 1 in 100 year flood line or delineated riparian area as measured from the middle of the watercourse measured on both banks, or within a 500 m radius of the boundary of any wetland.**	

Table 9: Detections – How quickly/easily can the impacts/risks of the activity be observed on the resource quality, people and property? Derived from the DWS Risk Matrix Impact Assessment method (GN 509).

Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5

Table 10: Significance rating score and risk classes based on the DWS Risk Matrix Impact Assessment method (GN 509).

SIGNIFICNACE RATING	RISK CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. **Licence required.**
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. **Licence required.**

3.3. Limitations

General limitations that affect the accuracy of information represented within this report include the following.

- Wetland areas within transformed landscapes, such as previously cultivated lands or mining areas with existing infrastructure, are often affected by disturbances that restrict the use of available wetland indicators, such as hydrophytic vegetation or soil indicators (e.g. as a result of the dominance of alien vegetation, stock piling, sedimentation, hard surfaces, and infilling).
- The survey was conducted during a single survey in early November and had experienced very low rainfall in the early growing season prior the survey (pers. comm. Mr Gunther Wiegenhagen[1]). The majority of the area was also very heavily grazed at the time of the field survey. The difficulty of identifying wetland plant species was therefore greatly increased and some species were in an unidentifiable state.

4. STUDY AREA DESCRIPTION

4.1. Location and Land Use

The study area is situated in the North-West Province approximately 7 km southeast of Stilfontein in an area situated approximately 1.23 km north and 0.38 km west of the Vaal River. Surrounding areas include Khuma Township to the north (± 1 km) and the old Buffelsfontein Mine to the west (± 100 m), (Figure 1). The proposed infrastructure footprints are included in a study area of 1495.5 ha, situated directly adjacent to the northern boundary of the current Mine Waste Solution surface rights area, on portions of the farms Buffelsfontein 443 IP, Hartebeestfontein 442 IP, Megadam 574 IP, Kareerand 444 IP and finally Kromdraai 420 IP in the east.
TSF.

The central parts of the southern boundary of the study area abut directly on the existing 564ha TSF. There is little existing infrastructure within the study area itself. Existing infrastructure comprises a guard house, a pipeline, a small laydown area and engineered dirt roads associated with the existing TSF, as well as farming related infrastructure such as dirt tracks, a small cement reservoir adjacent to the small endorheic pan (Site 31) and two abandoned farm homesteads in the eastern parts of the study area on the farms Kromdraai and Kareerand.

The assessed study area has a total area of 2060 ha and a combined size of 2794 ha with the surrounding 500 m study area buffer (Figure 1; Table 11). Individual features associated with the proposed infrastructure features are summarised in Table 11. Construction of the existing Kareerand TSF only started in 2011. There is little existing infrastructure within the study area itself. Existing infrastructure comprises a guard house, a pipeline, a small laydown area and engineered dirt roads associated with the existing TSF, as well as farming related infrastructure such as dirt tracks, a small cement reservoir adjacent to the small endorheic pan and two abandoned farm homesteads in the eastern parts of the study area on the farms Kromdraai and Kareerand. Three recently abandoned (ca. 6 years ago), centre pivot irrigation fields are also present in the eastern parts of the farm Kromdraai.

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[1] Mr Gunther Wiegenhagen is a Senior Environmental Coordinator Biodiversity and Closure Planning at Anglo Gold Ashanti.

The existing TSF has been fenced-off by a 2m game fence for security purposes, and the fence is situated 50m to 390m form the retaining wall of the TSF. Grazing and fire have been excluded from the fenced security area for some 8 years, and the vegetation is highly moribund. An approximately 157ha area in the south-western parts of the study area, situated on the farm Buffelsfontein, is situated within a game fenced area belonging to MWS which is heavily grazed by game animals. The western portions of the study area situated on the farms Kareerand and Kromdraai are fenced with normal cattle fencing and used for grazing by commercial cattle farmers. The remainder of the study area is unfenced, is not subjected to any form of access control and is regularly burnt and heavily grazed by cattle belonging to residents of Khuma. Small holdings are present on and upslope of the right hand bank of the Vaal River in the eastern-most section of the 500 m study area buffer (Figure 1).

Table 11: Summarises the surface area of the study area, 500 m study area buffer and proposed infrastructure footprints (also refer to Figure 1).

Study Area Component	**Surface Area in Hectare**
Study area	1495.5 ha
Study area with surrounding 500 m buffer	2793.7 ha
Existing Kareerand TSF	564 ha
Proposed TSF extension within the study area	382.6 ha
Combined Kareerand TSF with the new TSF extension included	946.6 ha
Burrow pits (three in total)	666.3 ha
Return water dams (four in total)	43.2 ha

4.2. Catchment and River Setting

The study area and its 500 m buffer is located within the Vaal Water Management Area (WMA). Previously, before the combination of the Vaal WMA into a single primary catchment, the division between the Middle Vaal and Upper Vaal WMAs transected the study area in a western and eastern section. The Ecoregion Classification for South African Rivers indicates that the study area forms part of the Highveld (11) category.

Three quaternary catchments overlap with the study area, namely C24A with a narrow sliver of the study area in the western-most section, C24B with the central and largest portion of the study area and C23L with the eastern section. All three of the quaternary catchments are ‘largely modified’ (category D Present Ecological State), while their Ecological Importance and Sensitivity (EIS) categories range from high to moderate (Middleton and Bailey, 2008). The mean annual precipitation (MAP) for the quaternary catchments range between 584-619 mm, while the mean annual evaporation (MAE) range between 1700-1750 mm.

The Present Ecological Status (PES) of the sub-quaternary Vaal River reaches, located in close proximity to study area (upstream and downstream), namely C23L-1845, C24B-1817 and C24B-1868, range between a category B (largely natural) and D (largely modified). The Ecological Importance (EI) and Ecological Sensitivity (ES) range between moderate and high (DWS, 2015). Kotze (2017) states that the PES of the Vaal decreases incrementally downstream (category B, then C and then D), indicating downstream deterioration due to an increased gradient of impacts and users.

4.3. North West Province Biodiversity Sector Plan (NWBSP) and Threatened Ecosystems

According to the NWBSP 2015, the Ecosystem threat status of two of the vegetation types occurring within the study area is as follows:

- Vaal Reefs Dolomite Sinkhole Woodland (**Not Currently Threatened**), and
- Rand Highveld Grassland (**Endangered**).

The North West Province Biodiversity Sector Plan (NWBSP) (North West Department of Rural, Environment and Agricultural Development, 2015), indicates Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) for the entire province, which is referred to as the CBA Map in the NWBSP. Categories used in the CBA Map are as follows:

- Protected Areas – declared and formally protected under the Protected Areas Act, such as National Parks, legally declared Nature reserves, World Heritage Sites and Protected Environments that are secured by appropriate legal mechanisms.
- Critical Biodiversity Areas (CBAs) – terrestrial and aquatic areas of the landscape that need to be maintained in a natural or near natural state in order to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services. In other words, if these areas are not maintained in a natural or near-natural state, then biodiversity targets cannot be met. Maintaining an area in a natural state can include a variety of biodiversity compatible land uses and resource uses.
- Ecological Support Areas (ESAs) – terrestrial and aquatic areas that are not essential for meeting biodiversity representation targets (thresholds), but which nevertheless play an important role in supporting the ecological functioning of critical biodiversity areas and/or in delivering ecosystem services that support socio-economic development, such as water provision, flood mitigation or carbon sequestration. The degree or extent of restriction on land use and resource use in these areas may be lower than that recommended for CBA's.
- Other Natural Areas - remaining natural areas not included in the above CBA or ESA categories. Degraded areas falling with the CBA and ESA categories. Areas that still contain natural habitat but that are not require to meet biodiversity targets.
- No Natural Habitat Remaining – areas that have been irreversibly modified (i.e. transformed) and do not contribute to maintaining biodiversity pattern or ecological processes. These include urban and rural settlements, crop lands, mining areas and forest plantations.

The entire study area fall within areas mapped as Critical Biodiversity Area - Category 1 (CBA 1) or Critical Biodiversity Area - Category 2 (CBA 2). The principal 'Land Management Objectives' for CBA 1 and CBA 2 areas provided in the NWBSP 2015 are reproduced in the 'text box' provided below.

In terms of managing the loss of natural habitat in CBAs, the NWBSP 2015 states, amongst others, that '**further loss of natural habitat should be avoided in CBA 1, whereas loss should be minimised in CBA 2, i.e. land in these two categories should be maintained as natural vegetation cover as far as possible**'. The CBA categories present in the study area are briefly discussed below based on the description provided by De Castro (2018).

TEXT BOX (extracted from Table 12 of the NWBSP 2015)	
CBA Map category	Land Management Objective
CBA 1	**Maintain in a natural or near natural state that maximises the retention of biodiversity pattern and ecological process**: • Ecosystems and species fully or largely intact and undisturbed. • These are areas with high irreplaceability or low flexibility in terms of meeting biodiversity pattern targets. If the biodiversity features targeted in these areas are lost then targets will not be met. • These are biodiversity features that are at, or beyond, their limits of acceptable change
CBA 2	**Maintain in a natural or near natural state that maximises the retention of biodiversity pattern and ecological process**: • Ecosystems and species fully or largely intact and undisturbed. • Areas with intermediate irreplaceability or some flexibility in terms of meeting biodiversity targets. There are options for loss of some components of biodiversity in these landscapes without compromising the ability to achieve biodiversity targets, although the loss of these sites would require alternative sites to be added to the portfolio of CBAs. • These are biodiversity features that are approaching, but have not surpassed their limits of acceptable change.

Approximately 1 126.5ha (or 75.3%) of the study area is classified in the NWBSP 2015 as CBA 2 and the remaining 369.0ha (or 24.7%) of the study area is classified as CBA 1. The area of CBA 1 comprises the north-eastern portions of the study area on the farms Kareerand and Kromdraai. The area classified as CBA 2 comprises mostly of untransformed habitats and vegetation, but approximately 37% of the area comprises secondary vegetation of habitats transformed by historical cultivation and, to a lesser extent, a plantation of alien trees, infrastructure and seepage from the existing TSF. The area classified as CBA 1 also comprises mostly of untransformed habitats and vegetation, but approximately 45% comprises secondary vegetation of habitats transformed by historical cultivation (including disused center pivot fields) and, to a lesser extent, two abandoned homesteads.

5. RESULTS

5.1. Watercourse Delineation and Classification

No natural or artificial wetlands overlap with the study area as indicated in the National Freshwater Ecosystem Priority Area (NFEPA) spatial dataset of Nel *et al*. (2011) (Figure 2). Only a potential floodplain wetland associated with the Vaal River overlaps partially with in the eastern-most portion of the 500 m study area buffer (Figure 2). Riparian and/or wetland habitat is expected to have developed on the right hand bank of the Vaal River, but the river ecosystem with its associated bed and banks does not form part of this study.

The 2013-13 South African National Land Cover dataset (GTI, 2015) indicates the presence of wetland areas within the study area and 500 m study area buffer (Figure 2). First and second order river lines from the 1:50000 topographical map 2626DD tend to overlap with these wetland land cover areas in the study area and its 500 m buffer (Figure 2). This indicates that headwater tributaries of the Vaal River present in the study area and its surroundings are likely to contain wetland habitat along their reaches, or at least portions of their reaches. The national land cover dataset also indicates the presence of wetlands and permanent water within the existing Kareerand TSF, which is to be expected as the facility stores water and seepage is expected from its foot slopes (Figure 2).

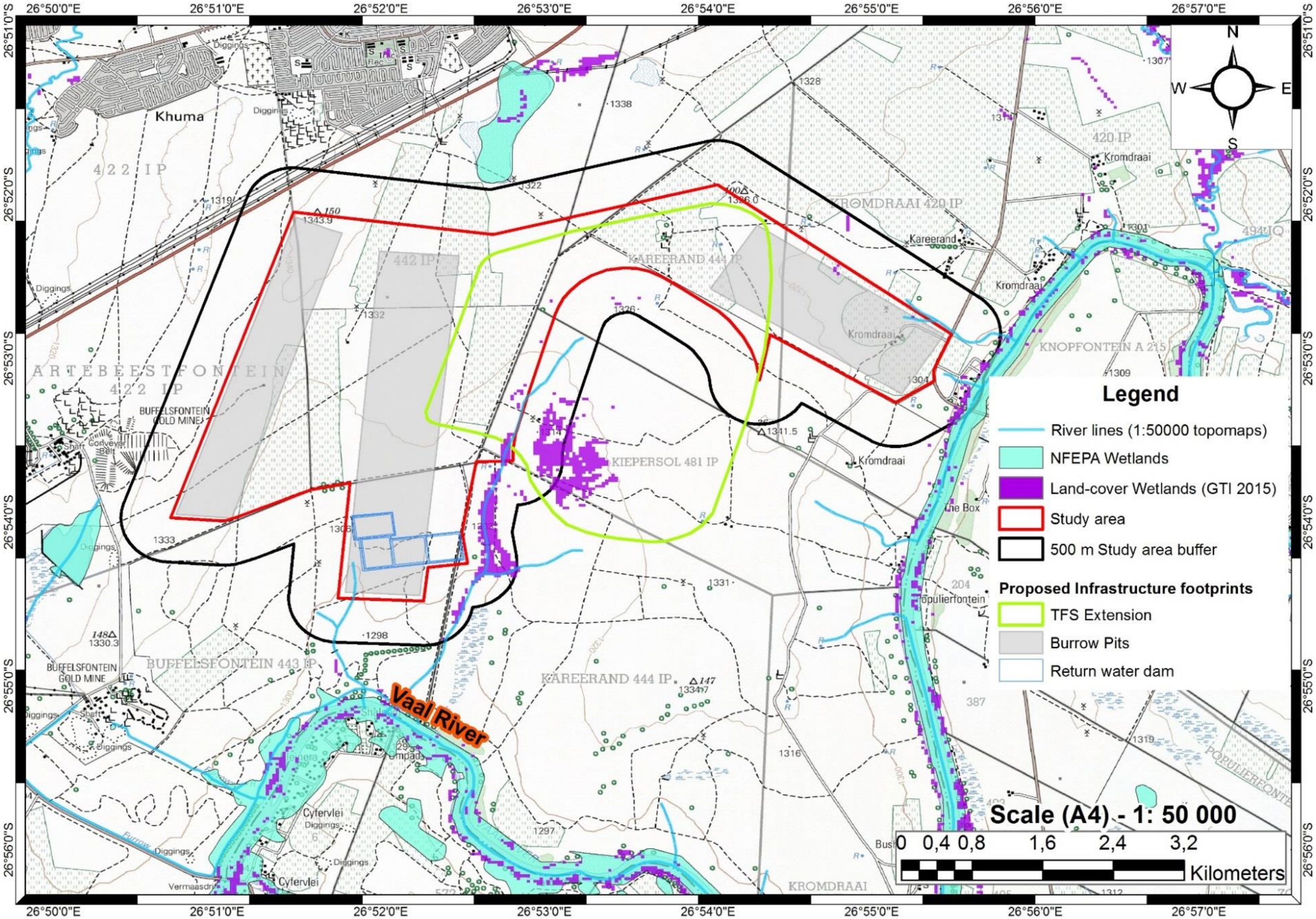

Figure 2: Illustrates the study area and proposed infrastructure footprints along with possible wetland areas obtained from existing spatial datasets available in the public domain, such as the NFEPA Wetlands (Net *et al*., 2011) and the 2013-2014 National Land Cover dataset (GTI, 2015).

The November site survey confirmed the presence of wetland habitat within the study area and along headwater drainage lines indicated on topographical map 2626DD. Recorded wetland indicators included hydromorphic features, such as gleying, low chroma matrix colours, spots of iron depletion and mottling, while hydrophyte (DWAF, 2005 & 2008) and hygrophyte (Retief & Herman, 1997) species were also identified. Natural wetlands were classified into four different types of hydro-geomorphic (HGM) units, while identified man-made wetlands were classified as artificial systems (Table 12; Figure 3):

- 3 x Unchannelled valley bottom wetlands
- 2 x Channelled valley bottom wetlands
- 2 x Seep wetlands
- 1 x Pan (depression) wetland
- 2 x Artificial wetlands

Table 12: Indicates the size of different types of delineated wetlands within the study area and surrounding 500 m study area buffer. Wetland numbers are used in tables and figures to reference and identify individual wetlands.

Wetland Type	**Wetland Number**	**Surface area in study area and 500m buffer**	**Surface area in study area only**
Unchannelled valley bottom wetland	1	13.26 ha	1.90 ha
Channelled valley bottom wetland	2	28.94 ha	6.02 ha
Seep wetland	3	6.27 ha	6.27 ha
Artificial wetland	4	1.52 ha	1.52 ha
Artificial wetland	5	1.01 ha	0.67 ha
Channelled valley bottom wetland	6	15.02 ha	9.30 ha
Seep wetland	7	6.80 ha	6.80 ha
Unchannelled valley bottom wetland	8	2.42 ha	-
Unchannelled valley bottom wetland	9	9.20 ha	-
Pan wetland	10	0.72 ha	0.72 ha
Total		**85.17 ha**	**33.21 ha**

5.1.1. Channelled and Unchannelled Valley Bottom Wetlands

All three valley bottom wetlands present within the study area, remain unchannelled within the study area boundary (wetlands 1, 2 and 6), (Figure 3). Both valley bottom wetlands 2 and 6 become weakly channelled downstream of the study area. Their channel features do become better defined closer to their confluences with the Vaal River. Each of the five identified valley bottom wetlands form tributaries of the Vaal River, with wetlands 2 and 6 classified as channelled valley bottom wetlands. Wetland 1 only has a short section with a minor discontinuous channel that can best be described as a swale. The lack of a well-developed channel and the flat topography of the area result in wetland 1 being classified as an unchannelled valley bottom wetland. The remaining two valley bottom wetlands, wetlands 8 and 9, are also classified as unchannelled valley bottom wetlands, but neither of them overlap with the study area (Figure 3).

The transition between channelled and unchannelled valley bottom wetlands is gradual and indistinct in the area due to gentle slopes and limited hard surface development in upstream catchments. All five valley bottom wetlands are characterised by heavy clay soils with desiccation cracks. Hydromorphic properties were not easily discernible at all sample points, as is often the case in areas with high clay content soils, such as vertic landscapes.

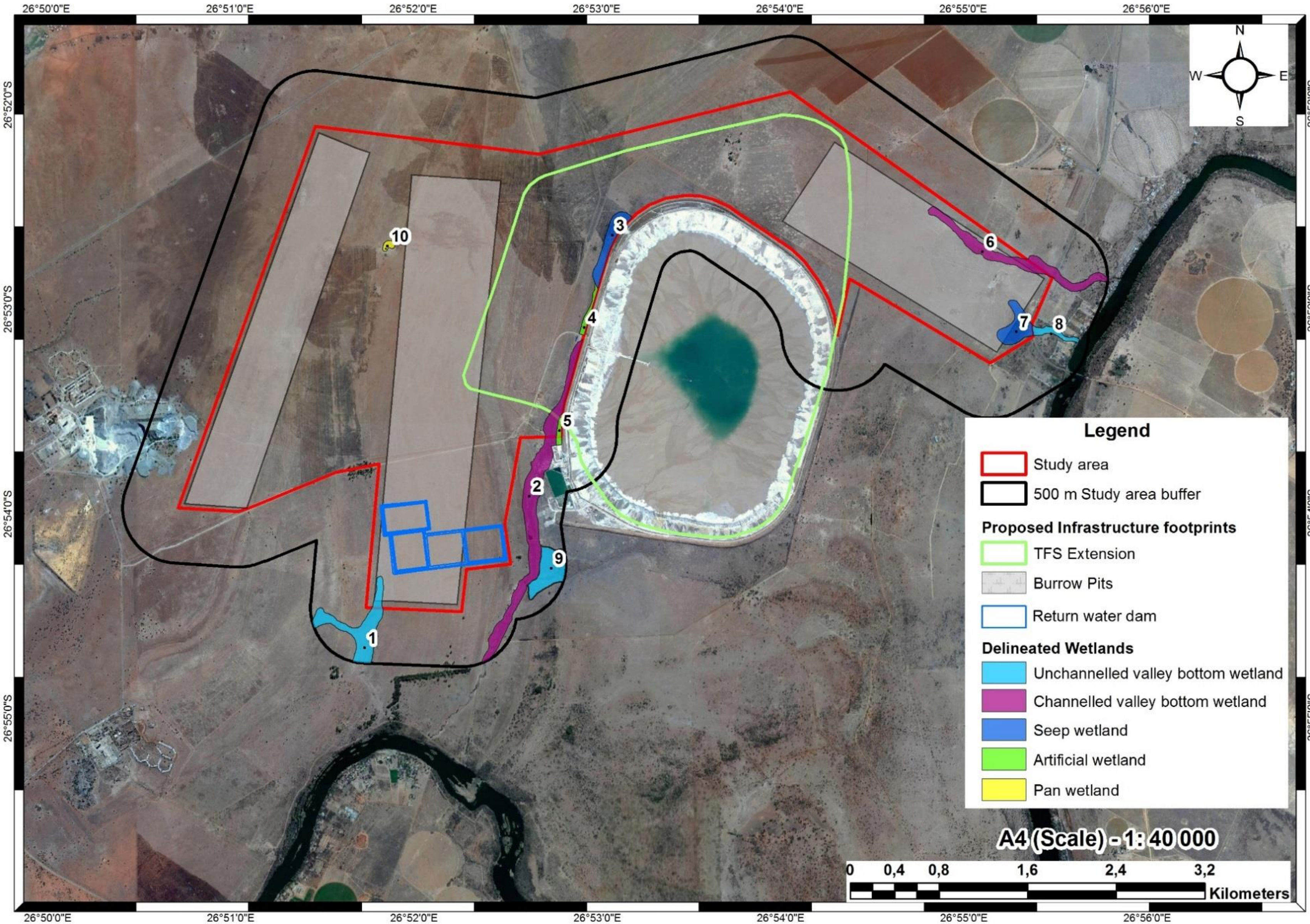

Figure 3: Illustrates delineated wetlands within the study area and its surrounding 500 m buffer. Numbers are used as map labels to refer to specific wetlands for reference purposes throughout the report.

Recorded hydromorphic indicators included distinct signs of gleying and G-horizons in the top soil profile in the centre of valley bottom wetlands (Figure 4). The outer wetland margins were often less clayey and contained mottles surrounded by areas of iron depletion, which were also indicative of wetland conditions (Figure 4; DWAF 2005 and 2008). A shallow pebble layer restricted soil sampling in the upper reach of unchannelled valley bottom wetland 1, but augering was possible at a headcut that confirmed signs of gleying below the pebble layer.

High grazing pressure and low rainfall during early spring resulted in a vegetation cover that constrained species identification in many instances. This coupled with indistinct channel development and high clay content soils, which did not consistently display hydromorphic features, resulted on the reliance of additional wetland indicators to help delineate valley bottom wetland boundaries. These included the use of terrain unit indicators, such as valley bottom settings, the presence of swales and channels, and the interpretation of available aerial imagery that included a georeferenced historical aerial photograph from 1939.

Channelled valley bottom wetland 2 is partially overlaid by the current TSF, which results in seepage from the TSF along the toe of the facility into the wetland. Toe seepage into the wetland has resulted in the elongated zone of *Typha capensis*, an obligate hydrophyte, along the length of the TSF/wetland boundary (Figure 5). Seepage from the existing TSF can also be inferred by the extensive presence of tailing sediments in the wetland from the TSF-wetland boundary towards the confluence with the Vaal River (Figure 5), as well as a very high EC level of 540 mS/m that was measured in the wetland during a survey in November 2017 by Kotze (2017). The halophyte and alien, *Tamarix ramosissima,* was recorded in valley bottom wetland 2, outside of the study area, but downstream of the existing TSF. This species is indicative of saline conditions and often establish on areas where tailing material has been deposited. Channelled valley bottom wetland 2 is the only valley bottom wetland with permanent wetness zones dominated by *Typha* capensis, in spite of the prolonged drought in the area. It is believed that the wetland is currently wetter than before the operation of the existing TSF and also has a suspected lower water quality as a result. Water input with a high salinity has reduced species diversity in portions of the wetland, such as areas affected by tailing deposition. At first glance the wetland portion in the study area may be regarded an artificial wetland caused by the TSF. Channelled valley bottom wetland 2, however, existed prior to the construction of the existing Kareerand TSF and is visible on the aerial photograph from 1939, as well as more recent time series imagery in Google Earth Pro prior to the construction of the Kareerand TSF. It still contains areas with a higher species richness of indigenous hydrophytes and hygrophytes compared to identified artificial wetlands in the study area (De Castro, 2018). Common indigenous species include the sedges *Cyperus longus, Bulbostylis humilis, Eleocharis dregeana Kyllinga erecta,* and the grasses *Agrostis lachnantha, Cynodon dactylon, Eragrostis micrantha, Hemarthria altissima, Helictotrichon turgidulum, Setaria sphacelata* and *Themeda triandra* (De Castro, 2018). Areas with a high cover of *Falkia oblonga* were also recorded downstream of the study area in sections with noticeable tailing depositions (Figure 5). The thickness of these tailing layers indicate alluvial deposition and not windblown depositions.

Figure 4: Illustrates wetland indicators in the form of gleying with distinct grey colours recorded in a soil sample with a high clay content from near the centre of a valley bottom wetland (left); and a sample from the outer portion of a valley bottom wetland with orange mottling and surrounding light grey areas caused by iron depletion due to a fluctuation in soil saturation typical of a temporary wetness zone (right).

Figure 5: Toe seepage from the existing TSF into channelled valley bottom wetland 2 is visible along the edge of the footprint and the presence of a corresponding linear zone of *Typha capensis*, an obligate hydrophyte, in the northern section of the wetland (left); and evidence of tailing depositions within valley bottom wetland 2 downstream of the existing TSF in an area colonised by the hydrophyte *Falkia oblonga* (right).

Valley bottom wetlands 1, 6 and 8 do not overlap with the existing Kareerand TSF and only temporary to seasonal wetness zones were recorded. Channelled valley bottom wetland 6 forms a long narrow and indistinct wetland heavy black clay soils that contained a central pivot irrigation system that was functional and cultivated until at least 2011. Obligate hydrophyte species were not recorded in this particular wetland, but species that indicate increased soil moisture levels were recorded, such as *Jamesbittenia aurantiaca*. Dominant grasses in channelled valley bottom wetland 6 include *Aristida bipartita* and *Setaria incrassata*. Common grasses include *Andropogon appendiculatus, Brachiaria eruciformis, Cynodon dactylon, Digitaria eriantha* and *Themeda triandra*. Common forbs include *Acalypha indica, Berkheya radula, Crabbaea angustifolia, Monsonia angustifolia, Rhynchosia minima, Salvia runcinata* and *Senecio inornatus* (De Castro, 2018). Several of these species are typical of temporary wetness zones in wetlands characterised by heavy black clays soils.

Unchannelled valley bottom wetland 9 is located entirely outside of the study area, but also partially overlaps with the existing TSF, similar to valley bottom wetland 2, although only delineated within the 500 m study area buffer (Figure 3). Interpretation of time series aerial images of the wetland in Google Earth Pro indicate that 'reed beds" of tall emergent aquatic macrophytes consisting of *Typha capensis* and *Phragmites australis* increased in the central zone of the wetland after construction of the existing TSF started in 2011. The expansion of *T. capensis* and *P australis* is contributed to increased wetness and salinity in the wetland due to seepage from the existing mega tailings facility, similar as in channelled valley bottom wetland 2.

5.1.3. Seep Wetlands

Two seep wetlands were identified and occur within the study area. Seep wetland 3 is located upstream of channelled valley bottom wetland 2, while seep wetland 7 is located directly upstream of unchannelled valley bottom wetland 8 (Figure 3). Both seep wetlands originally formed a continuum with these two valley bottom wetlands and the transition from one to the other is indistinct due the flat gradient, similar heavy clay soils and similar species composition in both seep and upper valley bottom HGM units. The connection between Seep wetland 3 and channelled valley bottom wetland 2 has however been cut-off from by the construction of the existing Kareerand TSF (Figures 3 and 6). Seep wetland 7 has remaining connectivity to unchannelled valley bottom wetland 8 and is only separated by a dirt road crossing. The large majority of seep wetland 7 has been converted into cultivated land through an irrigated central pivot system that was operation until 2011/2012 and now contains alien species associated with early succession in old lands such as, *Bidens pilosa*, *Cirsium vulgare*, *Verbena officinalis* and *Xanthium strumarium*.

Hydromorphic indicators recorded in seep wetland 3 included the presence of a G horizon with signs of gleying at a depth of approximately 0.3 m, in the centre of the upstream portion of the wetland (Figure 6). Seepage from the toe of the existing TSF into the wetland was also recorded along the remaining eastern edge of the wetland that borders the encroached TSF. Seepage in this portion of the wetland is also expressed in the development of a long linear zone of the obligate hydrophyte *Typha capensis*, similar as in channelled valley bottom wetland 2, albeit with a narrower width. Time series aerial imagery indicate that the *T. capensis* dominated zone is a new feature that was absent in the wetland prior to the operation of the mega tailings facility. Artificial seepage is therefore present in the wetland and has resulted in a wetter system with an expected high salinity compared to its reference condition. The presence of a well-developed G horizon in the centre of the upper seep, located approximately 70 m west from the berm at the edge of the TSF (coordinates 26°52'33.60"S 26°53'7.40"E), is highly unlikely to have developed as a result of seepage from the TSF over the last 6 years. The Rensburg/Katspruit soil form with its distinct G horizon would have required a much longer period of time to develop. Seep wetland 3 is therefore not regarded as an artificial wetland, but as a natural wetland, with its original hydrological connection to channelled valley bottom wetland 2 having been cut-off by the construction of the Kareerand TSF.

The wetland receives artificial water input in the form of seepage from the TSF. This new source of water input in combination with the severe modification of the topography of the wetland and permanent habitat loss caused by the encroachment of the TSF into the seep, resulted in a new artificial flow path has been created along the western edge of the TSF. Seepage water inputs from the TSF and natural water inputs into the wetland now flows from the remaining portion of the seep towards channelled alley bottom wetland 2 along an area that was previously terrestrial (see artificial wetland 4), (Figure 3). Desiccation cracks are common on the surface of seep wetland 3 and vertic clays are expected to be present.

Seep wetlands 3 and 7 more closely resemble wetland flats compared to typical seep wetlands, due to the flat topography and restricted lateral water movement in the heavy clay dominated topsoil profile, due to the low hydrological conductivity of the soils. Lateral interflow is typically the main driver of seepage wetlands (Ollis *et al*., 2013), but these black turf soil associated wetlands are still regarded as seeps as the HGM unit currently provides the best fit for these ecosystems.

Digitaria eriantha is the dominant grass in seep wetland 3, while subdominant grasses include *Eragrostis curvula* and *Themeda triandra*. Common species include the grasses *Cynodon dactylon* and *Setaria sphacelata*, as well as the forbs *Conyza podocephala, Senecio inornatus*, *Polygala hottentota*, *Berkheya* cf. *pinnatifida* subsp. *ingrata* and the alien *Verbena officinalis.* The small hygrophyte forb, *Lotononis listii*, was also recorded in the wetland.

Figure 6: Seep wetland 3 that has been cut-off completely from channelled valley bottom wetland 2 by the existing TSF (top); gleying in a heavy clay content soil in the upstream portion of seep wetland 2 (bottom left) and downstream portion (bottom right).

5.1.4. Artificial Wetlands

Two small artificial wetlands with a combined size of 2.53 ha were identified immediately west of the existing TSF in an area where no evidence of pre-development wetlands were found, as interpreted from historical aerial imagery. Seepage along the western boundary from the TSF is expected to be responsible for the formation of artificial wetlands 4 and 5 with a characteristic long narrow zone dominated by patches of the obligate hydrophyte *Typha capensis*. Time series imagery indicated no signs of elongated and dense patches of *T. capensis* along the western boundary of the TSF, prior to the operation of the facility.

Artificial wetland 4 is located in a narrow strip parallel to the TSF, along its suspected seepage line. It receives water input in the form of direct seepage from the TSF and from seep wetland 3 due to the modified flow pattern caused by the construction of the TSF. Artificial wetland 4 connects the upstream seep wetland 3 with channelled valley bottom wetland 2 downstream (Figure 3). Artificial wetland 5 occupies habitat in between channelled valley bottom 2 and the edge of the TSF, which again appears to function as a source of water input into the artificial wetland (Figure 3). Improved seepage control measures in the existing TSF is expected to reduce wetness in the two artificial wetlands and the wetlands may even seize to exist. This would also reduce low water quality input from the TSF into the wetlands, although wind-blown tailing material will continue to be deposited in the area. Existing return water dams along the base of the TSF are located outside of the study area and were not regarded as artificial wetlands, as they form inherently part of the infrastructure of the TSF (Figure 3).

Both of the artificial wetlands contain heavy clay soils that are expected to be conducive for surface ponding should a regular water source be present in the area such as, potential seepage from the TSF. The vegetation has very low species richness, and is dominated by hardy indigenous species that are mostly obligate or facultative halophytes and often act as pioneers on soils contaminated by tailings effluent. Vegetation surrounding these *Typha* reed beds comprises secondary hygrophilous grassland usually completed dominated by *Cynodon dactylon* (an obligate hydrophyte and facultative halophyte). Subdominant species include the grasses *Digitaria eriantha* and *Eragrostis trichophora*. Common species include the grasses *Eragrotis curvula, Eragrostis gummiflua, Eragrostis micratha, Calamagrostis epigeios* and the alien *Paspalum dilatatum**. Common forbs include *Pentzia incana* and the aliens *Cirsium vulgare* and *Oenothera rosea* (De Castro, 2018).

5.1.5. Pan Wetland

A single small pan wetland of 0.72 ha was identified in the north-western portion of the study area. Pans, also known as depression wetlands are defined by Ollis *et al*. (2013) as:

> ‘Inland aquatic ecosystem with closed (or near-closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. Dominant water sources are precipitation, groundwater discharge, interflow and diffuse (or concentrated) overland flow. Dominant hydrodynamics are primarily seasonal with resultant vertical fluctuations (Ollis *et al*., 2013).

The delineated pan includes a central zone, which forms the largest portion of the wetland and a narrow peripheral zone around it of approximately 3-4 m wide. A small seep is connected to the pan is situated immediately to the north of the pan. The seep is small enough to have been delineated as part of the pan and is also located within the pan basin. The central zone contains heavy clay soils that are dry, trampled and largely bare due to the late onset of the wet season and a high grazing pressure (Figure 7). Soils are shallow and approximately 0.15 m deep in the centre of the pan The dominant species in the central zone is the obligate hydrophyte grass *Diplachne fusca*, which had a canopy cover of approximately 5% (De Castro, 2018). The pan is underlain by ferricrete, or hard plintic horizon, which is exposed on the surface in areas. The shallow ferricrete layer is expected to form an impermeable or semi-impermeable aquitard that cyclically creates saturated soil conditions followed by surface ponding after sufficient rainfall. The pan can be best described as an ephemeral pan that can be dry for several months at a time followed by periodic inundation. The central zone is associated with seasonal wetness based on the presence of the obligate grass *Diplachne fusca* and frequency of mottles in the soil profile, while the remainder of the wetland is associated with temporary wetness.

The only other species recorded in the central zone were and unidentified sedge and the forbs *Alternathera sessilis, Rumex lanceolatus* and the alien *Gomphrena closiodes.* The narrow peripheral zone surrounding the central zone has a vegetation canopy cover of approximately 60%, with *Cynodon dactylon* as the dominant species. Other recorded grasses included *Eragrostis curvula* and *Diplachne fusca,* which is rare in this zone. Common forbs include *Alternathera sessilis, Bergia decumbens, Bergia pentheriana, Indigofera cryptantha* and the alien *Gomphrena celosiodes* (De Castro, 2018). Hydromorphic features were recorded in this zone and include mottling that is ≥ 10 % of the soil matrix. Mottles are surrounded by areas of iron removal (spots of Fe depletion) that is characterised by low chroma colours.

The seep section on the northern portion of the pan is vegetated by hygrophilous grassland indicative of soils which experience temporary saturation. Vegetation canopy cover is approximately 85%. The dominant species are the grasses *Themeda triandra* and *Eragrostis curvula*. Common grasses include *Eragrostis chloromelas, Eragrostis micrantha, Cymbopogon caesius, Cynodon dacgtylon* and *Eragrostis lehmanniana* subsp. *lehmanniana.* Common forbs include *Bergia decumbens, Bulbine narcissifolia, Gomphrena celosiodes, Helichrysum aureonitens, Hypoxis hemerocallidea, Lotononis listii* and *Vahlia capensis* (De Castro, 2018).

Figure 7: Pan wetland 10 is heavily grazed and contains a man-made dam, but no surface ponding was recorded in the wetland during the start of the growing season (November 2017).

5.2. Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) Assessments

Each of the delineated wetlands were assessed in terms of their Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS). The scale of the PES assessment considered wetland habitat that extend beyond the boundaries of the study area and even the 500 m study area buffer in one instance (unchannelled valley bottom 9). This was done in order to assess the health of the HGM wetland units from their origin to the edge of the 500 m study area buffer. Present Ecological State (PES) categories of assessed wetlands range from 'Unmodified' (category A) to 'Seriously modified' (category E), (Figure 8; Tables 1, 13, 15, 17 and 20).

Ecological Importance Sensitivity (EIS) categories of assessed wetlands range from High (category B) to Low/Marginal (category D), (Table 2, 14, 16, 18, 19 and 21). The assessed level of confidence associated with the EIS categories range from Moderate to Low /Marginal due to the unidentifiable state of wetland vegetation in many instances. The EIS method also enable the assessment of other ecosystem services such as, the hydro-functional importance and direct human benefits of assessed wetlands. Specific emphasis was placed on the occurrence of 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) within delineated wetlands or the presence of suitable habitat for these species. The following approach and information have been obtained specifically for assessed wetlands based on the Botanical Biodiversity Impact Assessment Report for the study area (De Castro, 2018).

A list of all plant 'species of conservation concern' (*sensu* Raimondo *et al.,* 2009) historically recorded from the quarter degree grid square within which the study area is situated (2626DD), as well as the grids immediately to the west (2626DC and 2626CD), south-west (2726BA), as obtained from the Plants of Southern Africa website (http://newposa.sanbi.org., downloaded in January 2018). Conservation status categories were also obtained from the latest Red Data List of South African Plants (Raimondo et al., 2009 and http://redlist.sanbi.org, downloaded January 2018).

The Red List of South African Plants (Raimondo *et al*., 2009 and http://redlist.sanbi.org) provides an assessment of all South African Plant taxa. The Red List therefore contains species that are currently regarded as being threatened with extinction (Critically Endangered, Endangered and Vulnerable) or are close to being threatened with extinction (Near Threatened), as well as species that are currently not regarded as being threatened with extinction (Least Concern), in accordance with IUCN Version 3.1 criteria (IUCN, 2001). In addition to the IUCN categories, the South African Red List also includes unique categories for species which do not currently qualify as Threatened or Near Threatened in accordance with IUCN criteria, and are thus categorised as Least Concern by the IUCN, but which are of some conservation concern (Raimondo *et al*., 2009). These South Africa categories are Critically Rare, Rare and Declining, and were developed specifically to highlight species that though not threatened with extinction possibly require some conservation effort and monitoring. In terms of the recommended methodology provided by Raimondo *et al*. (2009), the term 'species of conservation concern' includes the IUCN threatened and Near Threatened categories as well as the South African Red List categories (i.e. Critically Rare, Rare and Declining) and this approach was applied here (De Castro, 2018).

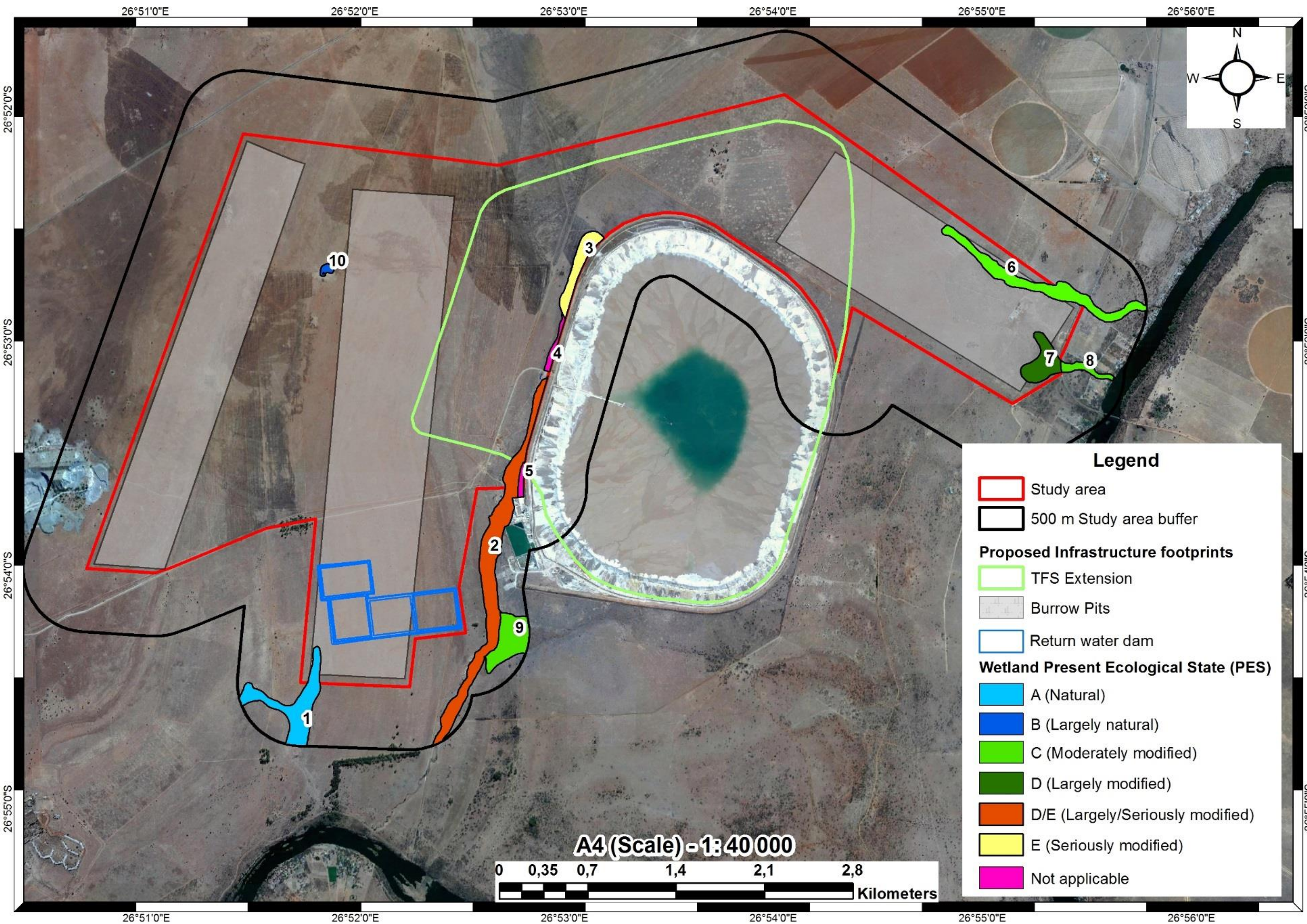

Figure 8: Delineated wetlands in the study area and surrounding 500 m buffer with different colours that indicate the PES of each natural wetland.

The lists for all four grids contained only one plant 'species of conservation concern', namely *Hypoxis hemerocallidea*, which was recorded from the grid 2626DC. All other species are those recorded during the current botanical biodiversity survey of the MWS Kareerand TSF Extension Project study area or during previous surveys conducted in the MWS surface rights area (2626DD) and Vaal Reefs Mine Complex surface rights area (2626DC) between 2007 and 2017 by De Castro (2018).

The obtained lists of historically and actual recorded 'species of conservation concern' from the study area and surroundings, which occur within delineated wetland areas present in the study area and its 500 m buffer, include the following (De Castro, 2018):

- *Crinum bulbispermum* (Declining) - Along rivers and streams or in damp depressions in black clay or sandy soil. In the authors experience always occurs in areas that are seasonally or at least periodically flooded. Undulating grasslands in damp, moist areas; the plants grow in full sun in damp depressions, near pans or on the edges of streams; grassland, riverbanks, vleis.
- *Eucomis autumnalis* (Declining) - On hillslope seeps in open grassland, and also along the margins of marshes.
- *Hypoxis hemerocallidea* (Declining) - In the author's experience, in the Highveld region of Gauteng, North-West and Mpumalanga this species occurs in various types of grassland including moist grassland on wetland margins and secondary grassland of historically cultivated soils. Raimondo *et al*. (2009) state that this species occurs in a wide range of habitats, including sandy hills on the margins of dune forests, open, rocky grassland, dry, stony, grassy slopes, mountain slopes and plateaus.

No recorded individuals or suitable habitat for *Nerine gracilis* (Vulnerable), a wetland associated species (hydrophyte) that was recorded on an adjacent site within 10 km of the study area, was identified during the November 2017 survey (De Castro, 2018).

5.2.1. Unchannelled Valley Bottom Wetlands

The PES categories for delineated unchannelled valley bottoms range from A (Unmodified) in the case of unchannelled valley bottom wetland 1, to C (moderately modified) for unchannelled valley bottoms 8 and 9 (Figure 8; Table 13). Unchannelled valley bottom wetland 1 also has a higher EIS (category B) compared to the two remaining unchannelled valley bottom wetlands that both have a Moderate EIS (Table 14). Ecosystem services associated with hydrological benefits such as, flood attenuation, stream flow regulation and water quality enhancement, and direct human benefits that include the provision of harvestable resources and cultivated food, range from Low/Marginal to none (Table 14).

Unchannelled valley bottom 1 is largely undisturbed and located within the nature reserve component of the study area. A high grazing pressure is present and a headcut erosion feature, but the system remains in a near pristine condition. The EIS of the wetland is regarded as High as the Declining species *Hypoxis hemerocallidea* was recorded therein, while overlap with the Vulnerable Rand Highveld vegetation unit is also present (NWBSP, 2015).

Both remaining unchannelled valley bottom wetlands were not surveyed for 'species of conservation concern', as they are located outside of the study area. Unchannelled valley bottom 8 is impacted by road infrastructure encroachment, the presence of a small dam and edge effects from adjacent small holding developments. Unchannelled valley bottom wetland 9 starts upstream of the 500 m study area boundary and has been directly impacted upon by the existing Kareerand TSF. This includes increased wetness that is reflected in the development of dense stands of rushes and reeds (*Typha capensis* and *Phragmites australis*) based on time series aerial image interpretation, which were not present prior to the operation of the TSF. Expected low quality water inputs caused by seepage from the TSF into the wetland is also expected, as well as the encroachment of a portion of the TSF footprint into the upper reach of the wetland (Figure 8). Habitat loss caused by TSF infrastructure encroachment is less compared to channelled valley bottom wetland 2.

Table 13: PES impacts scores and categories for individual PES components (hydrology, geomorphology and vegetation), as well as the combined impact score and PES category for unchannelled valley bottom wetlands 1, 8 and 9.

		Unchannelled valley bottom wetland 1	**Unchannelled valley bottom wetland 8**	**Unchannelled valley bottom wetland 9**
Hydrology	Impact score	1.0	3.5	3.0
	PES category	**B**	**C**	**C**
Geomorphology	Impact score	0.3	1.6	5.4
	PES category	**A**	**B**	**D**
Vegetation	Impact score	1.5	3.1	2.4
	PES category	**B**	**C**	**C**
Ecological Category (PES)	**Impact score**	0.92	2.86	3.51
	PES category	**A**	**C**	**C**

Table 14: EIS, hydro-functional importance and direct human benefits scores and categories for unchannelled valley bottom wetlands 1, 8 and 9.

	Unchannelled valley bottom wetland 1	**Unchannelled valley bottom wetland 8**	**Unchannelled valley bottom wetland 9**
Ecological Importance and Sensitivity (EIS) score	3.3	2.4	2.7
Ecological Importance and Sensitivity (EIS) Category	**B**	**C**	**C**
	High	**Moderate**	**Moderate**
Hydro-functional Importance score	1.8	1.4	2.1
Hydro-functional Importance Category	**D**	**D**	**D**
	Low/Marginal	**Low/Marginal**	**Low/Marginal**
Direct Human Benefits score	1.0	0.7	0.7
Direct Human Benefits Category	**E**	**E**	**E**
	None	**None**	**None**
Overall Level of Confidence Category	**Moderate**	**Moderate**	**Moderate**

5.2.2. Channelled Valley Bottom Wetlands

Both of the channelled valley bottoms have a weakly developed channel only that only becomes visible downstream of the study area. The PES assessment of channelled valley bottom wetland 2 indicated a Largely modified PES (category D), (Figure 8; Table 15). The applied PES assessment method does not take water quality into account to determine the health of the wetland (Macfarlane *et al*., 2008), which means that wetlands affected by low water quality inputs can be in a lower ecological category compared to the calculated score. Kotze (2017) reports that the high EC measured in channelled valley bottom wetland 2 (540 mS/m), is an indication that some sources of high salinity is entering the wetland, which in return contributes to salt loads in the downstream Vaal River. Probable sources of pollution that may impact on the wetland include Khuma Township and the existing Kareerand TSF (Kotze, 2017). Seepage and runoff from the TSF are regarded as the most likely sources of high salinity in the wetland is, as extensive alluvial tailing depositions were recorded within channelled valley bottom wetland 2. The PES of the wetland has therefore been reduced from Largely modified (category D) to Largely/Seriously modified (category D/E) due to known low water quality inputs that will most certainly affect the wetland (Table 15). Other impacts affecting the wetland include encroach of the existing TSF into the wetland, as well as associated return water dams and road crossings. An in-channel dam is located approximately 830 m downstream of the study area in the wetland.

Channelled valley bottom wetland 6 has a Moderately modified PES (category C) and overlaps partially with old cultivated lands that include an abandoned central pivot field (Figure 8; Table 15). Ruderal and agrestal weeds have subsequently encroached into old lands present in the wetland and include species such as, *Bidens bipinnata, Schkuhria pinnata, Verbena officinalis* and *Xanthium strumarium*. Other impacts include a dirt road crossing and a high grazing pressure immediately downstream of the study area. The wetland catchment remains well intact but overlaps partially with the existing TSF.

The EIS of both channelled valley bottom wetland are calculated as Moderate (Table 16). Channelled valley bottom wetland 2 scores slightly higher as two declining species, namely *Crinum bulbispermum* and *Hypoxis hemerocallidea*, were recorded within its boundaries as delineated within the 500 m study area buffer (De Castro, 2018), (Table 16). Hydro-functional importance and direct human benefits associated with the two wetlands are generally Low/Marginal to none-existent, with the exception of water quality enhancement performed by channelled valley bottom wetland 2. This pertains specifically to the opportunity and ability of remaining wetland to trap tailings through sedimentation in areas that remain well vegetated. The possible expansion of the TSF and further deterioration of the wetland are expected to reduce the ability of the wetland to trap tailing material downstream of the existing TSF due to an expected increase in the volume of tailing influxes and a loss of vegetated wetland surfaces.

Table 15: PES impacts scores and categories for individual PES components (hydrology, geomorphology and vegetation), as well as the combined impact score and PES category for channelled valley bottom wetlands 2 and 6.

		Channelled valley bottom wetland 2	**Channelled valley bottom wetland 6**
Hydrology	Impact score	6.5	2.0
	PES category	**E**	**C**
Geomorphology	Impact score	6.4	1.6
	PES category	**E**	**B**
Vegetation	Impact score	4.7	3.9
	PES category	**D**	**C**
Ecological Category (PES)	**Impact score**	5.97	2.43
	Calculated PES category	**D**	**C**
	Refined Ecological Category (PES)	**D/E**	Same as above

Table 16: EIS, hydro-functional importance and direct human benefits values and categories for channelled valley bottom wetlands 2 and 6.

	Channelled valley bottom wetland 2	**Channelled valley bottom wetland 6**
Ecological Importance and Sensitivity (EIS) score	2.7	2.4
Ecological Importance and Sensitivity (EIS) Category	**C**	**C**
	Moderate	**Moderate**
Hydro-functional Importance score	3.1	1.4
Hydro-functional Importance Category	**B**	**D**
	High	**Low/Marginal**
Direct Human Benefits score	0.7	0.7
Direct Human Benefits Category	**E**	**E**
	None	**None**
Overall Level of Confidence Category	**Moderate**	**Moderate**

5.2.3. Seep Wetlands

Seep wetland 3 is the most transformed of all of the assessed wetland systems and is regarded as Seriously modified (category E PES), (Figure 8; Table 17). The majority of seep wetland 3 has been permanently lost due to the encroachment of the Kareerand TSF into the wetland, which has also disconnected the original hydrological connectivity between the seep and channelled valley bottom wetland 2. Seepage from the TSF has increased the wetness of the wetland, as is evident in the increase in *Typha capensis* since the TSF became operational, and also functions as a source of expected low quality water input. Seep wetland 7, located in the eastern portion of the study area, has a Largely modified PES (category D), as the majority of the wetland was transformed into a central pivot irrigation field that has been unused for the last six years (Figure 8; Table 17).

The EIS categories of both wetlands are regarded as Low/Marginal, with no 'species of conservation concern' recorded (Table 18). Hydro-functional importance, such as water quality enhancement, is regarded as Low/Marginal to None (Table 18). Tailing material present in seep wetland 3 appear not to have been deposited via runoff (alluvial processes) from the TSF, but through windblown (aeolian) processes. Tailings depositions are shallower compared to channelled valley bottom wetland 2. They are furthermore not concentrated in seep wetland 3, but also occur outside of it on adjacent terrestrial habitat, resulting in a category E score for hydro-functional importance (Table 18). Direct human benefits such as, the provision of water for human use and the value of the wetlands for tourism and recreation, both fall within EIS category E (None), (Table 18).

Table 17: PES impacts scores and categories for individual PES components (hydrology, geomorphology and vegetation), as well as the combined impact score and PES category for seep wetlands 3 and 7.

		Seep wetland 3	**Seep wetland 7**
Hydrology	Impact score	7.0	3.5
	PES category	**E**	**C**
Geomorphology	Impact score	7.0	1.4
	PES category	**E**	**B**
Vegetation	Impact score	7.8	7.8
	PES category	**E**	**E**
Ecological Category (PES)	**Impact score**	7.24	4.10
	Calculated PES category	**E**	**D**

Table 18: EIS, hydro-functional importance and direct human benefits values and categories for seep wetlands 3 and 7.

	Seep wetland 3	**Seep wetland 7**
Ecological Importance and Sensitivity (EIS) score	1.8	1.6
Ecological Importance and Sensitivity (EIS) Category	**D** **Low/Marginal**	**D** **Low/Marginal**
Hydro-functional Importance score	1.0	1.1
Hydro-functional Importance Category	**E** **None**	**D** **Low/Marginal**
Direct Human Benefits score	0.5	0.3
Direct Human Benefits Category	**E** **None**	**E** **None**
Overall Level of Confidence Category	**Moderate**	**Low/Marginal**

5.2.4. Artificial Wetlands

No PES categories can be assigned to the two artificial wetlands as they existed as terrestrial areas prior to the development of the Kareerand TSF. They border channelled valley bottom wetland 2 and the exact division between the two man-made and natural wetland is difficult to determine with certainty. Seepage conditions that were created during the construction and operational phases of the TSF has led to the formation of artificial wetlands over the last six years. Wetland species have therefore become established in areas where anthropogenically enhanced soil moisture conditions developed. The two artificial wetlands therefore have a non-wetland reference state, which excludes the application of PES assessments.

The EIS of the two artificial wetlands are not dependent on the reference state of the systems, but on their ability to support biodiversity and their inherent sensitivity to environmental changes (e.g. changes in hydrology and water quality). Both of the assessed artificial wetlands have a category E EIS, which is the lowest possible category (Tables 2 and 19). Seepage from the existing tailings facility has not only severely impacted on the hydrology of these areas, but has in all likelihood also led to increased levels of salinity in the wetlands. The impact of an increase in salinity is reflected in the species composition of the wetland vegetation, which has a low diversity (species richness) when compared to natural wetlands within the study area. The artificial wetlands are also dominated by facultative halophytes, such as *Typha capensis* and *Cynodon dactylon*. Neither of the artificial wetlands contain suitable habitat for any of the wetland-associated plant 'species of conservation concern' recorded within the study area. Hydro-functioning and direct ecosystem services for human benefit provided by the two wetlands range also falls within the lowest possible category (E), (Tables 2 and19).

Table 19: EIS, hydro-functional importance and direct human benefits values and categories for artificial wetlands 4 and 5.

	Artificial wetland 4	**Artificial wetland 5**
Ecological Importance and Sensitivity (EIS) score	1.0	1.0
Ecological Importance and Sensitivity (EIS) Category	**E** **None**	**E** **None**
Hydro-functional Importance score	1.0	1.0
Hydro-functional Importance Category	**E** **None**	**E** **None**
Direct Human Benefits score	0.3	0.3
Direct Human Benefits Category	**E** **None**	**E** **None**
Overall Level of Confidence Category	**Moderate**	**Low/Marginal**

5.2.5. Pan Wetland

The species richness, stand structure and even species dominance of different vegetation zones in the pan wetland is likely to vary markedly from season to season, as is typical for ephemeral/seasonal pans. This constrains the definition of what defines the reference condition for a pan, as its wetness and vegetation communities can vary largely over time due to natural rainfall cycles. A naturally seasonal pan can therefore have a pristine reference condition in both the wet and dry state. The PES of the pan wetland is assessed as Moderately natural (category B) in spite of these constraints, which include the presence of very dry conditions at the time of the assessment (Table 20). The pan has been heavily grazed at the time of the survey and it is likely that the vegetation of both the pan and its associated small seep have been historically overgrazed. Other impacts include the presence of the small concrete dam that has no significant influence on the hydrology of the wetland, while a few alien species, such as *Gomphrena celosiodes, Richardia brasiliensis* and *Persicaria lapathifolia* were also recorded.

The EIS of the Pan is High (category B), specifically in terms of its value as a spatially restricted ecosystem, as it is the only pan wetland identified within the study area and the 500 m study area buffer. A large pan wetland is indicated on the NFEPA Wetlands dataset is located approximately 50 m north of the 500 m study area buffer, but falls outside the scope of this study (Figure 2). Pans are often associated with unique biodiversity and become important breeding areas for different fauna species once water is present. They are sensitive to water quality changes as they are inward draining and therefore accumulate pollutants released within their catchment. Pan wetland 10 scores a low value for hydro-functional importance as it is hydrologically isolated from the rest of the drainage network and provides zero contribution to stream flow regulation and flood attenuation ecosystem services (Table 21). The score for direct human benefits falls also in the lowest category.

Table 20: PES impacts scores and overall PES category for pan wetland 10 based on the method developed by Kleynhans (DWAF, 1999).

Criteria and attributes	Relevance	Score	Confidence
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	4	3
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	3	3
Water Quality			
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland	4	2
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	3	2

Criteria and attributes	Relevance	Score	Confidence
Hydraulic / Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	5	4
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns.	3	3
Biota			
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	4	2
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	3	2
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	4	3
Alien fauna	Presence of alien fauna affecting faunal community structure.	5	2
Overutilisation of biota	Overgrazing, Over-fishing, etc	2	2
TOTAL:		40	28
MEAN:		3.63	2.54
PES CLASS		**B**	
Level of confidence		High/Moderate	

Scoring guidelines per attribute: Natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; Largely modified = 2; Seriously modified = 1; and Critically modified = 0.
Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/Low confidence = 1.

Table 21: EIS, hydro-functional importance and direct human benefits values and categories for pan wetland 10.

	Pan wetland 10
Ecological Importance and Sensitivity (EIS) score	3.2
Ecological Importance and Sensitivity (EIS) Category	**B**
	High
Hydro-functional Importance score	0.9
Hydro-functional Importance Category	**E**
	None
Direct Human Benefits score	0.8
Direct Human Benefits Category	**E**
	None
Overall Level of Confidence Category	**Moderate**

6. DISCUSSION AND RISK MATRIX IMPACT ASSESSMENT

6.1. Proposed Infrastructure Footprints, Wetlands, Buffers and Layout Considerations

All of the delineated wetlands illustrated in Figure 9 are habitats that are protected by national environmental legislation, as they are regarded as watercourses that are defined in the National Water Act (Act 36 of 1998) (NWA). This includes both natural and artificial wetlands.

Information obtained from the wetland study should firstly be used to create an environmentally sensitive layout design that avoids wetland impacts as far as possible by locating infrastructure features away from delineated wetlands as illustrated in Figure 9. Part of this process of impact avoidance, which is regarded as the primary means of impact mitigation, involves the demarcation of a setback area, or a buffer, which consists of terrestrial habitat located between the outer edge of the watercourse and the start of the development footprint. Buffer zones located around watercourses are known to perform several diverse functions and have become a standard mitigation measure to protect watercourses from different types of impacts associated with the construction, operational and decommissioning phases of proposed projects. These functions include the following (Castelle *et al.* 1992; ELI, 2008; Macfarlane *et al.*, 2014):

- Maintaining basic aquatic processes.
- Reducing impacts on water resources from upstream activities and adjoining land uses by retaining pollutants.
- Sediment retention (e.g. through deposition).
- Lower erosion risk.
- Moderation of flows from uplands into wetlands.
- Providing habitat for aquatic and semi-aquatic species.
- Providing habitat for terrestrial species.
- Screen a wetland (and other watercourses) from adjacent developed areas.
- Limitation of direct human impacts on a wetland (e.g. waste disposal and trampling).
- A range of ancillary societal benefits.

In South Africa a fix width buffer zone recommendation for watercourses has been most prevalent historically and forms part of the approach followed by some provincial regulatory authorities, such as the Gauteng Department of Agriculture and Rural Development (GDARD). A recently published preliminary guideline document for the determination of buffers around rivers, wetlands and estuaries recommends that a modified fixed-width approach is regarded as most appropriate for the South African context (Macfarlane *et al.*, 2014). The document state the following as part of their proposed modified fixed-width approach:

> *"…proposes highly conservative buffer widths based on generic relationships for broad-scale assessments, but allows these to be modified based on more detailed site-level information. Resultant buffers therefore range from highly conservative, fixed widths for different land uses at a desktop level to buffers that are modified based on a more thorough understanding of the water resource and specific site characteristics".*

The buffer zone tool for the determination of aquatic impact buffers and additional set-back requirements for wetland ecosystems (Macfarlane *et al*, 2014) was used to assist in the development of recommended buffers. Different buffers were evaluated for different mining-associated land uses, such as proposed excavation activities (i.e. burrow pits and return water dams) and proposed mining waste storage facilities (i.e. return water dams and the TSF expansion area). This was done based on available information, which excluded any hydro-pedological evaluation of water movement properties in wetland and upslope terrestrial soils. Hydrological conductivity of soils was, however, inferred from recorded soil texture (e.g. high clay content) in and adjacent to wetland areas that informed calculations in the applied method. The buffer zone tool calculated a recommended buffer distance of 50 m around wetlands affected by shallow (low-risk) quarrying excavations (e.g. the proposed burrow pit areas) and a 77 m wide buffer around high risk plant and plant waste mining operations (e.g. the proposed return water dams and the TSF expansion area).

The location of burrow pits are not expected to be unmovable. It is assumed that burrow pits can be moved with relative ease depending on the type of material that is required for construction and rehabilitation. Moving burrow pits away from wetlands and wetland buffers is the most ideal form of mitigation. The impact assessment and associated mitigation recommendations are based on the assumption that it would be possible to move burrow pits away from buffered wetlands. The uncertainty regarding the depth of excavation activities in burrow pits and impacts on soil and sub-soil water movement patterns, resulted in the decision to increase the recommended buffer width from 50 m to 100 m for wetlands located in close proximity to burrow pits. The absence of a hydropedology study to help determine buffer distances more accurately also contributed to the increase in the recommended buffer distance. A 100 m as opposed to a 77 m wide buffer, is also recommended for wetlands located in close proximity to the proposed TSF expansion area and return water dams.

A 100 m wide buffer is therefore recommended for the following wetlands located within a 100 m radius of the study area (Figure 9; Table 22):

- Unchannelled valley bottom wetlands 1 and 8
- Channelled valley bottom wetland 6
- Seep wetland 7

At present a total wetland area of 11.87 ha overlaps with proposed burrow pit footprints (Table 22). Affected wetlands include unchannelled valley bottom wetland 1, channelled valley bottom wetland 6 and seep wetland 7 (Figure 9; Table 22). Two of the three proposed burrow pit footprints overlap with a combined area of 27.97 ha of the 100 m buffer around unchannelled valley bottom wetland 1, channelled valley bottom wetland 6 and seep wetland 7 (Figure 9; Table 22). It is recommended that the two affected proposed burrow pits be removed away from these three wetlands and more than 100 m beyond their boundaries (Figure 9).

The 77 m buffer calculated through the buffer determining method developed by Macfarlane *et al.* (2014) for channelled valley bottom wetland 2, was rounded off to 80 m. The 80 m buffer is slightly larger, more practical to communicate and helps to make provision for inaccuracies that may be associated with coordinates captured with the hand held GPS device that typically has an accuracy within 5 m. The buffer was determined for the ‘plant and plant waste’ land use associated with mining option provided in the buffer calculation method (Macfarlane *et al.*, 2014). The primary purpose of the buffer is not to retain and protect a remaining portion of the wetland catchment area, which has already been transformed in large part by the existing TSF, but to provide a well vegetated area where tailings sediment from the new TSF expansion can be filtered out through physical sedimentation. Sedimentation through vegetation filtering and reduced run off velocities is a known buffer function, especially in cases with a flat topography and where a non-point source of sediment release is expected. The need for trapping and preventing tailings material from entering channelled valley bottom wetland 2 is crucial. The deposition of tailing material in the channelled valley bottom wetland was recorded along the length of the delineated system. A buffer is also expected to help mitigate negative water quality impacts caused by increased seepage from the expanded TSF footprint, but is not expected to as effective as the removal of tailings sediment through sedimentation. It remains a concern for the impact on the water quality of the wetland, as well as the nearby Vaal River into which the wetland drains. The 80 m buffer will therefore help to mitigate impacts not only in the wetland, but also in the Vaal River. Its effectiveness is strongly dependant on the ongoing maintenance of the buffer to keep it well vegetated with indigenous grass species and free from roads, furrows, drains and erosion features.

An 80 m wide buffer as opposed to a 77 m wide buffer is recommended for channelled valley bottom wetland 2 around the proposed TSF expansion area (Figure 9; Table 22). This particular wetland is already partially destroyed by the existing TSF and has a Largely/Seriously modified PES, but its hydro-functional importance remains high, especially its importance to act as a sink for tailing sediments that are carried by runoff from the existing TSF. A wetland area 3.76 ha and an additional buffer area of 13.11 ha overlaps with the current proposed infrastructure layout. It is recommended that the proposed TSF extension footprint is moved out of channelled valley bottom 2 and that an 80 m wide setback area (buffer) is present from the edge of the TSF expansion area and the wetland (Figure 9; Table 22).

A preliminary 200 m minimum buffer is recommended for pan wetland 10 in order to protect the pan and its catchment. Impacts in pan catchment, such as low water quality inputs and sedimentation in pan catchments (basins), eventually accumulate within the pan due to its inward draining pattern (endorheic drainage). The recommended preliminary 200 minimum buffer around the pan wetland has therefore been demarcated to capture the core area of the pan catchment (Figure 9). It is recommended that the extent of the catchment should be determined more accurately using detailed contour line data that was not available during the compilation of this report. The entire pan catchment will therefore be regarded as sensitive and should not overlap with proposed burrow pit footprints. Currently 2.86 ha of the preliminary 200 m minimum buffer overlaps with one of the burrow pit footprints and should be moved (Figure 9; Table 22).

Seep wetland 3, along with artificial wetlands 4 and 5, are regarded as the wetlands with the lowest EIS, lowest PES, and lowest value in terms of hydro-functional importance and provision of direct human benefits in the study area (Section 5.2). The long-term management of artificial wetlands adjacent to the TSF is problematic as they are expected to deteriorate further over time due their increasing salinity from continued seepage out of tailings materials. Improved mitigation measures to help reduced seepage from the TSF and its existing return water dams may result in the gradual disappearance of the artificial wetlands over time.

Changes to the layout design of proposed burrow pits and return water dams are expected to be easier compared to the proposed expansion footprint of the TSF, as the expansion area needs to adjoin the existing TSF facility. Avoiding overlap between the TSF and channelled valley bottom wetland 2 and its recommended 80 m buffer, is regarded as the top avoidance priority with regards to layout change recommendations for the TSF expansion area (Figure 9). This is due to the strategic importance of channelled valley bottom wetland 2, which provides connectivity between the TSF and the Vaal River, and also functions as the primary sink for tailing materials that become mobilised and move from the TSF. It follows that overlap between the expansion area of the TSF and other wetlands that border the existing TSF, such as seep wetland 3 and artificial wetlands 4 and 5, may not be avoidable (Figure 9). The use of buffers around these wetlands are therefore currently constrained as it is assumed that impact avoidance is an unlikely means of mitigation due to the impracticality thereof in this instance. The current layout design of the proposed infrastructure footprints will result in a complete and permanent loss of seep wetland 3 and artificial wetland 4, while approximately 10 % of artificial wetland 5 could also be destroyed. Artificial wetland 5 will be protected as part of the 80 m buffer around channelled valley bottom wetland 2 (Figure 9).

The continued existence and operation of the two artificial wetlands are not regarded as a high priority for the continued protection of wetland habitat and ecosystem services. Seep wetland 3 is regarded as a natural wetland that receives seepage input from the TSF. It is, however, of lower ecological and hydrological value compared to channelled valley bottom wetland 2, which is also impacted (Section 5.2). Loss of the seep wetland will, however, still result in a measureable impact (Section 6.2). It is therefore recommended that the project proponents should also investigate the possibility of avoiding overlap between these three wetlands and the proposed TSF expansion area. Layout alternatives that should be considered include moving the TSF expansion area east and southeast, outside of the current study area, which will be dependent on the absence of other sensitive biophysical features in the area, including unknown wetlands. Further encroachment of the TSF into the upstream portion of unchannelled valley bottom 9, located outside of the current study area, should be avoided. Unchannelled valley bottom 9 extends beyond its delineated boundaries, which includes the area upstream of the 500 m study area buffer. The existing TSF footprint already partially overlaps with the wetland and should therefore not be expanded further south or in a south-western direction (Figure 9).

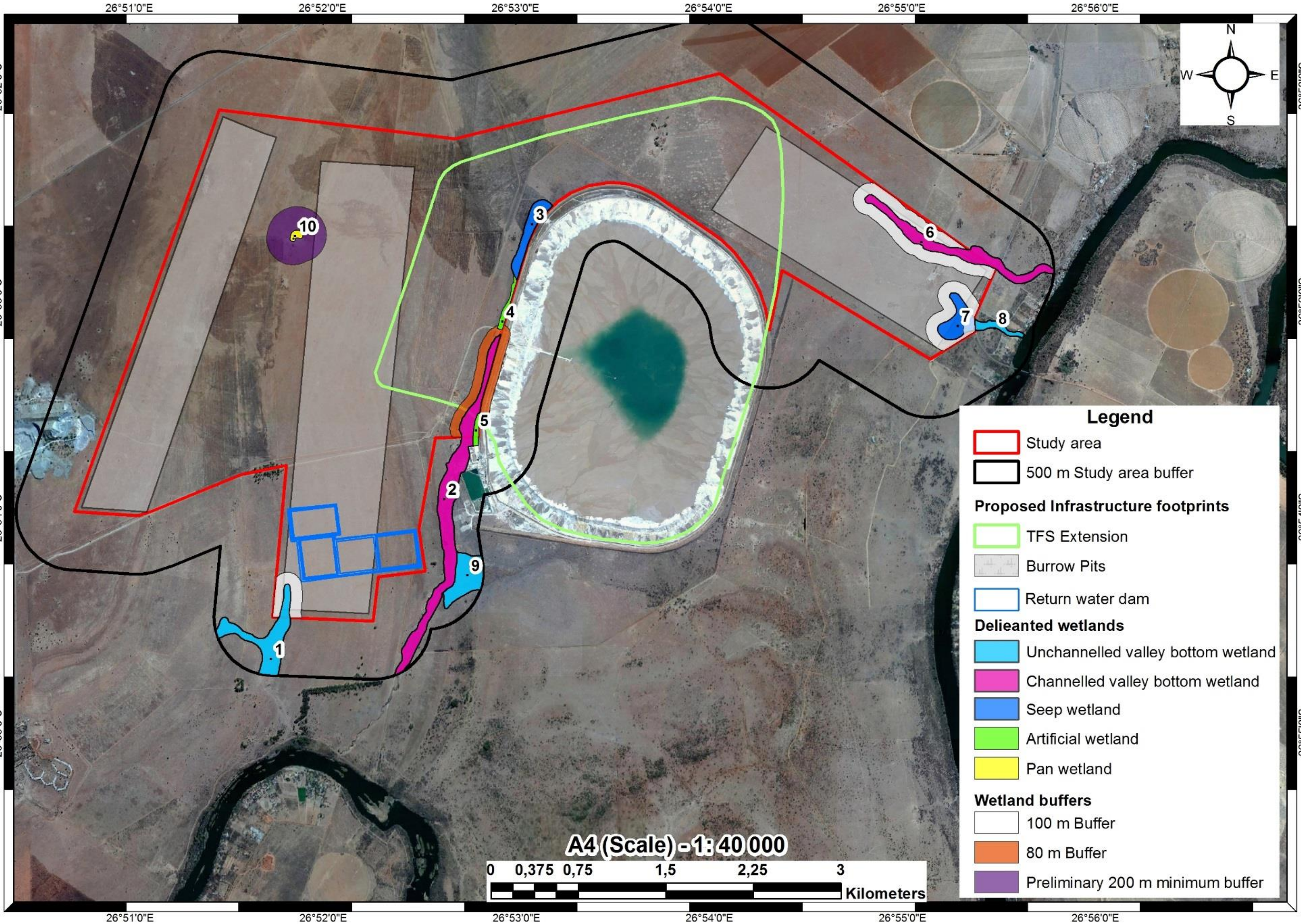

Figure 9: Delineated wetlands and recommended buffer zones within the study area and the surrounding 500m study area buffer.

Table 22: Summarises the overlap between delineated wetlands and proposed infrastructure footprints in the study area, as well as overlap between recommended wetland buffers and proposed infrastructure footprints in the study area (also refer to Figure 9).

Wetland Number	**Wetland Type**	**Surface area in study area and 500m buffer**	**Surface area in study area only**	**Overlap with TSF Extension**	**Overlap with burrow pits**	**Overlap with return water dams**	**Recommended buffer width**	**Buffer overlap with proposed infrastructure footprints**
1	Unchannelled valley bottom wetland	13.26 ha	1.90 ha	-	1.35 ha	-	100 m	See combined value for 100 m buffer overlap around this wetland, channelled valley bottom 6 and seep wetland 7 with burrow pits (total area of 27.97 ha)
2	Channelled valley bottom wetland	28.94 ha	6.02 ha	3.76 ha	-	-	80 m	13.11 ha (TSF Extension)
3	Seep wetland	6.27 ha	6.27 ha	6.27 ha	-	-	-	-
4	Artificial wetland	1.52 ha	1.52 ha	1.52 ha	-	-	-	-
5	Artificial wetland	1.01 ha	0.67 ha	0.10 ha	-	-	-	-
6	Channelled valley bottom wetland	15.02 ha	9.30 ha	-	7.82 ha	-	100 m	27.97 ha (Burrow pits) (Includes overlap with 100 m buffer around unchannelled valley bottom wetland 1)
7	Seep wetland	6.80 ha	6.80 ha	-	2.70 ha	-	100 m	
8	Unchannelled valley bottom wetland	2.42 ha	-	-	-	-	100 m	-
9	Unchannelled valley bottom wetland	9.20 ha	-	-	-	-	-	-
10	Pan wetland	0.72 ha	0.72 ha	-	-	-	200 m preliminary minimum buffer	2.86 ha (Burrow pit)
Total		**85.17 ha**	**33.21 ha**	**11.65 ha**	**11.87 ha**			**43.87 ha**

6.2. Risk Matrix Assessment and Recommended Mitigation Measures

Results from the Risk assessment protocol with associated matrix for expected project-related impacts, based on the impact assessment method published in GN 509 (26 August 2016), are provided in Table 23. The impact risk assessment table pertains specifically to Section 21 (*c*) and (*i*) water uses, as defined in the National Water Act (Act No. 36 of 1998) (NWA), which include:

(c) Impeding or diverting the flow of water in a watercourse
(i) Altering the bed, banks, course or characteristics of a watercourse

The DWS developed risk assessment protocol to assess impacts related to Section 21 (c) and (i) activities is encompassing and flexible enough that it can be used to assess the full range of potential project-related impacts that can affect identified wetlands. The method was modified to also incorporate the 'without mitigation' impact assessment scenario and tables provided can therefore also used as an impact assessment method for the EIA phase. Differentiation is also made between the Construction and Operational phases of the project. Tables 23 to 34 illustrate assessed impacts with and without mitigation for the construction and operational phases of the proposed development. The decommissioning, remnant and cumulative impacts are assessed through a descriptive approach.

It is important to note that the impact assessments with mitigation, will change in the event that recommended impact avoidance measures related to changes in the current infrastructure layout design, as described in Section 6.1, cannot be implemented for whatever reason. Changes to the proposed infrastructure footprints or the inability to implement other recommended mitigation measures will therefore require a re-evaluation of assessed impacts and can result in a change in impact rating categories. Identified impacts and their recommended mitigation measures are discussed below and assesses all delineated wetlands collectively as a single group, with the result that the worst (highest) impact affecting any of the wetlands will be reflected. This pertains specifically to the encroachment of the proposed TSF expansion area into seep wetland 3 and artificial wetlands 4 and 5, for which avoidance as a form of impact mitigation may not be possible (Section 6.1). The reader should refer to Figure 9, and Tables 22 to 34 throughout this section.

6.2.1. Activity 1: Expansion of the Tailing Storage Facility (TSF)

Identified aspects and associated impacts related to the expansion of the TSF include the following for the construction and operational phases of the project:

- TSF Infrastructure encroachment into wetlands will result in the permanent loss of wetland habitat within overlapping portions of the proposed footprint. Affected areas include the entire remaining portion of seep wetland 3, the entire area of artificial wetland 4 and a portion (14.93 %) of artificial wetland 5 (Figure 9; Table 22).
- Tailings material transported via runoff can result in the deposition of tailings within downstream wetlands. Channelled valley bottom wetland 2 is currently affected by alluvial tailing depositions from the existing TSF. The impact is expected to worsen with the proposed expansion of the TSF due to a larger area in the wetland catchment that can function as a source of tailings (Figure 9).
- Seepage from the new TSF extension area will result in the pollution of adjacent surface water resources (wetlands), with an expected increase in salinity. Channelled valley bottom wetland 2 and artificial wetland 5 are already impacted by seepage from the

existing TSF (Section 5). This impact is expected to worsen due to the proposed increase in size of the current TSF footprint within and around them (Figure 9).

- Refuelling of machinery during the construction phase can result in the spillage and/or inflow of hydrocarbons into wetlands. This is a general impact that can affect all of the delineated wetlands, including those located within or in close proximity to the TSF expansion footprint (Figure 9).
- Movement of heavy motorised vehicles (HMVs) in wetlands during the construction and operational phases will compact soils and along with other soil disturbances (see above), create an opportunity for the establishment of alien species. This is a general impact that can affect all of the delineated wetlands, including those located within or in close proximity to the TSF expansion footprint (Figure 9).

The implementation of recommended impact avoidance and mitigation measures listed below will result in risk classes that range from High (significance score 176) to Low (significance score 27), (Tables 10, 24 and 26). The recommended impact avoidance and mitigation measures include the following:

- The proposed TSF extension should be set back at a minimum distance of 80 m around channelled valley bottom 2 to avoid overlap and reduce the risk of seepage and deposition of tailings material in the wetland (Figure 9). The recommended 80 m buffer will also prevent overlap between artificial wetland 5 and the TSF expansion area (Figure 9). The buffer needs to be maintained to remain well vegetated and simultaneously be kept free of alien species for the duration of the operational phase.
- Prevention of overlap between the TSF expansion area, seep wetland 3 and artificial wetlands 4 is currently not expected to be possible, but should still be investigated as a potentially feasible alternative (Section 6.1). The assumed unavoidable overlap between the TSF expansion area and the above mentioned wetlands will create an impact that cannot be mitigated and has a High risk class associated with it (Table 24).
- The transportation of tailings material and deposition into downstream wetlands, particularly channelled valley bottom wetland 2, were initially assessed to result in a Moderate risk with a significance score of 160 (Tables 23 and 25). Alluvial tailing depositions were common in channelled valley bottom wetland 2, located downstream of the existing TSF. This impact is expected to worsen over time due of the increase in size of the current TSF. The impact can be reduced to a Low risk as provided in the risk matrix protocol (GN 509) through the implementation of the following mitigation measures (mitigation measures are indicated in red as they are regarded as essential to achieve a Low risk class, as recommended in GN 509) (Tables 24 and 26):
    - **Implementation of the 80 m setback area (buffer) between channelled valley bottom wetland 2 and the proposed TSF extension area.**
    - **Maintenance of the 80 m buffer to keep it functional by ensuring that it is well vegetated and free of alien plant species.**
    - **Construction of a containment berm around the TSF expansion area to help avoid tailings transported via runoff into downstream watercourses.**
    - **Containment structures of a sufficient size should be designed, implemented and maintained to remove tailing material from runoff during high rainfall or persistent rainfall events at outflow/overflow structures in the TSF expansion footprint. Provision should be made to incorporate water volumes associated with 1:50 and 1:100 year flood events.**
    - **The existing in-channel dam in channelled valley bottom wetland 2 located at coordinates 26°54'7.98"S 26°52'37.97"E, approximately 900 m south of**

the study area, can be utilised to help trap runoff-transported tailings. It is proposed that increased water storage capacity in the dam is created during the wet season through a pipeline and pump system that transport excess water from a predetermined water line in the dam to the proposed return water dams located toward the west or even the TSF itself (Figure 9). Tailing material that enters the upstream portion of the wetland during the wet season will be trapped more effectively in the dam, and should be periodically removed by dredging the dam and returning the tailings to the TSF.

- Seepage from the extended TSF was initially assessed to result in a Moderate risk with a significance score of 166 (Tables 23 and 25). The impact can be reduced to a Low risk as provided in the risk matrix protocol (GN 509) through the implementation of the following mitigation measures (mitigation measures are indicated in red as they are regarded as essential to achieve a Low risk class, as recommended in GN 509) (Tables 24 and 26):
  - **The use of an impermeable liner that covers the entire floor of the TSF expansion footprint is recommended along with a system that will intercept seepage from the toe of the TSF and return it to the centre of the TSF. Provision should be made for wetter than average years including water volumes associated with 1:50 and 1:100 year flood events.**
  - **Recommendations provided in the specialist geotechnical report should also be adhered to in order to reduce the risk of seepage from the TSF into adjacent terrestrial and wetland areas**.
- No refuelling or unauthorised driving should occur in delineated wetlands or their recommended buffer zones. Wetlands and buffers should be indicated on maps used during the construction phase and also clearly demarcated on site. Toolbox talks should include discussions that will refer to mapped and onsite demarcated wetland boundaries as sensitive areas that should be avoided, unless construction work is authorised in the wetland as part of a received Environmental Authorisation (EA) for the EIA and issued Integrated Water Use License (IWUL).
- The Master Layout Plan that forms part of the Integrated Water Use License and indicate approved infrastructure features along with buffered wetlands should be adhered to and made available to different construction crews and contractors.
- Temporary infrastructure features, such as construction roads, construction camps, laydown/stockyard areas and stockpiles should also be located outside of buffered wetlands unless authorised and indicated on the Master Layout Plan that forms part of the Integrated Water Use License Application (IWULA).
- Permanent roads that will be used during the operational phase should avoid overlap with delineated wetland areas and their buffers (Figure 9).
- Unauthorised driving in wetlands that result in vehicle track entrenchment can be ripped using manual labour or mechanical means, depending on the magnitude of the impact.
- Development of a site specific alien control plan during the early rehabilitation phase. This plan should be developed by an experienced botanist or wetland ecologist that will map problem areas and provide species specific recommendation to addressed alien established within delineated wetlands in the study area. The alien control plan should be updated and its implementation monitored during the rehabilitation phase (starting at the end of construction) and during the operational phase of the project.

The alien control plan can form part of a larger wetland rehabilitation plan that should be developed near the end of the construction phase to address remnant wetland impacts that were not sufficiently addressed during the construction phase.

Table 23: *Impact* assessment table for identifed wetland impacts associated with the proposed TSF expansion development during the construction phase, without mitigation.

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of	Frequency of	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Construction phase	Expansion of the TSF	Infrastructure encroachment into wetland habitat	Permanent loss of wetland habitat due to infrastructure encroachment; Sedimentation of tailings material in wetlands; Pollution of surface water resources (wetlands) due to received seepage from the TSF; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species into wetland areas.	5	5	5	5	5	1	5	11.0	5	5	5	1	16	176	**H**	70	Refer to Section 6.2.1.	
		Tailings material transported with runoff		1	5	3	3	3	2	5	10.0	4	5	5	2	16	160	**M**	60		
		Seepage from new TSF extension into wetland habitat		4	5	3	3	3.75	2	4	9.8	4	5	5	3	17	166	**M**	50		
		Refuelling of machinery in or adjacent to wetlands during the construction phase.		1	5	3	4	3.25	1	2	6.3	3	3	5	2	13	81	**M**	70		
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	4	2	2.5	1	2	5.5	3	3	5	1	12	66	**M**	60		

Table 24: Impact assessment table for identifed wetland impacts associated with the proposed TSF expansion development during the construction phase, with mitigation. This also represents the risk matrix impact table for the assessments of project-related Section 21 (c) and (i) water uses associated with the proposed TSF expansion project during it's construction phase, as per the the DWS risk asemssnt protocol (GN 509).

Phase	**Activity**	**Aspect**	**Impact**	**Flow Regime**	**Physico & Chemical**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**	**Frequency of**	**Frequency of impact**	**Legal Issues**	**Detection**	**Likelihood**	**Significance**	**Risk Rating**	**Confidence level**	**Control Measures**	**Borderline LOW MODERATE Rating Classes**
Construction phase	Expansion of the TSF	Infrastructure encroachment into wetland habitat	Permanent loss of wetland habitat due to infrastructure encroachment; Sedimentation of tailings material in wetlands; Pollution of surface water resources (wetlands) due to received seepage from the TSF and spillage of hydrocarbons during construction; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species in wetland areas	5	5	5	5	5	1	5	11.0	5	5	5	1	16	176	**H**	70	Refer to Section 6.2.1.	
		Tailings material transported with runoff		2	2	2	2	2	2	2	6.0	2	2	5	2	11	66	**M**	60		54
		Seepage from new TSF extension into wetland habitat		2	2	2	2	2	1	2	5.0	4	1	5	3	13	65	**M**	50		50
		Refuelling of machinery in or adjacent to wetlands during the construction phase.		1	1	1	1	1	1	1	3.0	1	1	5	2	9	27	**L**	80		
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	2	2	1	1	1	3.0	3	3	5	1	12	36	**L**	70		

Table 25: Impact assessment table for identifed wetland impacts associated with the proposed development during the operational phase, without mitigation.

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Operational phase	Operation of the expanded TSF	Tailings material transported with runoff	Sedimentation of tailings material in wetlands; Pollution of surface water resources (wetlands) due to received seepage from the TSF; Compaction of wetland soils due to the movement of HMVs; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species into wetland areas.	1	5	3	3	3	2	5	10.0	4	5	5	2	16	160	**M**	60	Refer to Section 6.2.1.	
		Seepage from new TSF extension into wetland habitat		4	5	3	3	3.75	2	4	9.8	4	5	5	3	17	166	**M**	50		
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	3	2	2.25	1	2	5.3	2	3	5	1	11	58	**M**	60		

Table 26: Impact assessment table for identifed wetland impacts associated with the proposed development during the operational phase, with mitigation. This also represents the risk matrix impact table for the assessments of project related Section 21 (c) and (i) water uses associated with the proposed TSF expansion project during it's operational phase, as per the the DWS risk assemssnt protocol (GN 509).

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Operational phase	Operation of the expanded TSF	Tailings material transported with runoff	Sedimentation of tailings material in wetlands; Pollution of surface water resources (wetlands) due to received seepage from the TSF; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species in wetland areas	2	2	2	2	2	2	2	6.0	2	2	5	2	11	66	**M**	60	Refer to Section 6.2.1.	54
		Seepage from new TSF extension into wetland habitat		2	2	2	2	2	1	2	5.0	4	1	5	3	13	65	**M**	50		50
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	2	2	1	1	1	3.0	3	3	5	1	12	36	**L**	70		

6.2.2. Activity 2: Excavation of burrow pits

Identified aspects and associated impacts related to the excavation of the three proposed burrow pits include the following for the construction and operational phases of the project:

- Soil excavation and vegetation clearing works in burrow pit footprints that overlap with wetlands will result in permanent loss of wetland habitat. The current development layout indicate that portions of unchannelled valley bottom 1, channelled valley bottom 6 and seep wetland 7 will be lost in this manner (Figure 9; Table 22).
- Soil excavation works in burrow pit footprints located upslope and in close proximity, to wetlands can result in the desiccation of wetland habitat due to a modified hydrology, which includes a reduction of surface inflows and a drawdown of the groundwater table. Affected areas include burrow pit footprints that overlap with terrestrial habitat in the recommended 100m wide buffer for HGM wetland units 1, 6 and 7, as well as a portion of the proposed 200 m preliminary minimum buffer around pan wetland 10 (Figure 9; Table 22).
- Stockpiling of excavated soil and subsoil material in wetlands will result in the loss of wetland vegetation and modification of wetland topography. Affected wetlands include HGM units 1, 6 and 7 (Figure 9; Table 22)
- Runoff from bare and unprotected soil and subsoil stockpiles in/or adjacent to wetlands can result in the deposition of ex situ soil material on wetland habitat, causing the smothering of wetland vegetation. Potentially affected wetlands include HGM units 1, 6, 7 and 10 (Figure 9; Table 22)
- Refuelling of machinery during construction can result in the spillage and/or inflow of hydrocarbons into wetlands. This is a general impact that can affect all of the delineated wetlands, including those located within or in close proximity to the burrow pit footprints (Figure 9).
- Movement of heavy motorised vehicles (HMVs) in wetlands will compact soils and along with other soil disturbances (see above), create an opportunity for the establishment of alien species. This is a general impact that can affect all of the delineated wetlands, including those located within or in close proximity to the burrow pit footprints (Figure 9).

The implementation of recommended impact avoidance and mitigation measures listed below will result in risk classes that range from the upper limit of the Low class (significance score 55) to the middle range of the Low class (significance score 27), (Tables 10, 28 and 29). The recommended impact avoidance and mitigation measures include the following:

- All burrow pits should be moved to terrestrial areas located outside of buffered wetlands, including 100 m and 200 m wetland buffers (Section 6.1; Figure 9). These buffers were determined through the buffer zone tool for the determination of aquatic impact buffers and additional set-back requirements for wetland ecosystems (Macfarlane *et al*, 2014). The calculated buffer size of 50 m wide was increased to 100 m (Section 6.1). The uncertainty regarding the depth of excavation activities in burrow pits and impacts on soil and sub-soil water movement patterns, resulted in the decision to increase the recommended buffer width from 50 m to 100 m for wetlands located in close proximity to burrow pits. The absence of a hydropedology study to help determine buffer distances more accurately also contributed to the increase in the recommended buffer distance.
- The entire pan wetland catchment area is regarded as sensitive to burrow pit excavation works and has been initially delineated through a 200 m preliminary minimum buffer around the pan wetland 10 (Figure 9). The pan wetland catchment area should be

determined and regarded as a sensitive area that will replace the 200 m preliminary minimum buffer, once detailed contour line information is available for the study area (Section 6.1). Alternatively the 200 m buffer around the pan wetland should be used as an approximation of the pan catchment.

- No burrow pits are currently located close to channelled valley bottom 2, but future layout changes that may move burrow pit footprints closer should incorporate the recommended 80 m buffer and increase it in size to 100 m, as is the case for other wetlands located in close proximity to burrow pit footprints (Section 6.1; Figure 9).
- Recommended buffers to protect wetlands from burrow pit excavation works are constrained by uncertainties, such as the depth of excavation activities and the hydropedological properties of wetland and upland soils. It is recommended that an opinion from a hydropedologist is obtained to help refine buffer distances between different wetlands and proposed burrow pits.
- Movement of burrow pits into the proposed TSF extension footprint can be considered, but this should not alter the permeability of material underlying the TSF expansion in an adverse manner that will increase the risk of seepage from the new TSF area into downstream wetlands. Nor should it risk the effectiveness of recommended mitigation measures, such as the proposed impermeable liner on the floor of the new TSF extension area (Section 6.2.1). Input from a geohydrologists and geotechnical specialist are recommended in this regard.
- Stockpiles should be located outside of all buffered wetlands and silt fences should be erected downslope of them to capture sediment runoff during the wet season. Silt fences should be repaired and maintained for the duration of the construction phase. Additional silt fences or silt bays should be used in the event that existing structures have insufficient capacity in spite of cleaning efforts.
- Refer to section 6.2.1. regarding a description of mitigation measures to address impacts associated with refuelling in wetlands, unauthorised driving in wetlands, the construction of temporary structures, the layout of permanent roads, and the development of a site specific alien control and rehabilitation plan.

Table 27: Impact assessment table for identifed wetland impacts associated with the three proposed burrow pits during the construction phase, without mitigation.

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of	Frequency of	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Construction phase	Excavation of burrow pits	Soil excavation in burrow pit footprints that overlap with wetlands	Permanent loss of wetland habitat during construction; Desiccation of wetland habitat due to modified hydrology, including surface inflows and drawdown of groundwater level into excavated areas upslope of wetlands; Loss of wetland vegetation and modification of wetland topography; Deposition of ex situ soil material on wetland vegetation (smothering of vegetation);	5	5	5	5	5	1	5	11.0	5	5	5	1	16	176	**H**	50	Refer to Section 6.2.2.	
		Soil excavation works in burrow pit footprints located upslope and in close proximity to wetlands		5	2	2	4	3.25	1	5	9.3	5	5	5	1	16	148	**M**	50		
		Stockpiling of excavated soil and subsoil material in wetlands		4	3	4	3	3.5	1	5	9.5	5	5	5	1	16	152	**M**	70		
		Runoff from bare and unprotected stockpiles in/or adjacent to wetlands		3	4	3	3	3.25	1	5	9.3	2	3	5	1	11	102	**M**	60		

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
		Refuelling of machinery in or adjacent to wetlands during the construction phase.	Pollution of surface water resources (wetlands) due to spillage of hydrocarbons during construction; Compaction of wetland soils; Encroachment of alien species into wetland habitat.	1	5	3	3	3	1	2	6.0	3	3	5	2	13	78	**M**	70		
		Movement of heavy motorised vehicles (HMVs) in wetlands	Pollution of surface water resources (wetlands) due to spillage of hydrocarbons during construction; Compaction of wetland soils; Encroachment of alien species into wetland habitat.	2	2	4	2	2.5	1	2	5.5	3	3	5	1	12	66	**M**	60		

Table 28*:* Impact assessment table for identifed wetland impacts associated with the three proposed burrow pits during the construction phase, with mitigation. This also represents the risk matrix impact table for the assessments of project related Section 21 (c) and (i) water uses associated with the proposed burrow pits during it's construction phase, as per the the DWS risk assemssnt protocol (GN 509).

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Construction phase	Excavation of burrow pits	Soil excavation in burrow pit footprints that overlap with wetlands	Permanent loss of wetland habitat during construction; Desiccation of wetland habitat due to modified hydrology, including surface inflows and drawdown of groundwater level into excavated areas upslope of wetlands; Loss of wetland vegetation and modification of wetland topography; Deposition of ex situ soil material on wetland vegetation	2	2	2	2	2	1	2	5.0	3	2	5	1	11	55	**L**	50	Refer to Section 6.2.2.	
		Soil excavation works in burrow pit footprints located upslope and in close proximity to wetlands		2	2	2	2	2	1	2	5.0	3	2	5	1	11	55	**L**	60		
		Stockpiling of excavated soil and subsoil material in wetlands		2	2	2	2	2	1	1	4.0	4	2	5	1	12	48	**L**	70		
		Runoff from bare and unprotected stockpiles in/or adjacent to wetlands		2	2	2	2	2	1	1	4.0	4	2	5	1	12	48	**L**	70		

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
		Refuelling of machinery in or adjacent to wetlands during the construction phase.	(smothering of vegetation); Pollution of surface water resources (wetlands) due to spillage of hydrocarbons during construction; Compaction of wetland soils; Encroachment of alien species into wetland habitat.	1	1	1	1	1	1	1	3.0	1	1	5	2	9	27	**L**	80		
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	2	2	2	1	1	4.0	3	3	5	1	12	48	**L**	70		

Table 29: Impact assessment table for identifed wetland impacts associated with the three proposed burrow pits during the operational phase, without mitigation.

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Operational phase	Open burrow pits	Soil excavations (cavities) in burrow pit footprints located upslope and in close proximity to wetlands	Desiccation of wetland habitat due to modified hydrology, including surface inflows and drawdown of groundwater level into excavated areas upslope of wetlands; Deposition of ex situ soil material on wetland vegetation (smothering of vegetation); Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species into wetland habitat.	5	2	2	4	3.25	1	5	9.3	5	5	5	1	16	148	**M**	50	Refer to Section 6.2.2.	
		Runoff from bare and unprotected stockpiles in/or adjacent to wetlands		3	3	3	3	3	1	5	9.0	2	2	5	1	10	90	**M**	60		
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	3	2	2.25	1	2	5.3	2	3	5	1	11	58	**M**	60		

Table 30: Impact assessment table for identifed wetland impacts associated with the three proposed burrow pits during the operational phase, with mitigation. This also represents the risk matrix impact table for the assessments of project related Section 21 (c) and (i) water uses associated with the proposed burrow pits during it's operational phase, as per the the DWS risk assemssnt protocol (GN 509).

Phase	**Activity**	**Aspect**	**Impact**	**Flow Regime**	**Physico & Chemical**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**	**Frequency of activity**	**Frequency of impact**	**Legal Issues**	**Detection**	**Likelihood**	**Significance**	**Risk Rating**	**Confidence level**	**Control Measures**	**Borderline LOW MODERATE Rating Classes**
Operational phase	Open burrow pits	Soil excavations (cavities) in burrow pit footprints located upslope and in close proximity to wetland	Desiccation of wetland habitat due to modified hydrology, including surface inflows and drawdown of groundwater level into excavated areas upslope of wetlands; Deposition of ex situ soil material on wetland vegetation (smothering of vegetation); Compaction of wetland soils; Encroachment of alien species into wetland habitat.	2	2	2	2	2	1	1	4.0	4	2	5	1	12	48	**L**	70	Refer to Section 6.2.2.	
		Runoff from bare and unprotected stockpiles in/or adjacent to wetlands		2	2	2	2	2	1	1	4.0	4	2	5	1	12	48	**L**	70		
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	2	2	2	1	1	4.0	3	3	5	1	12	48	**L**	70		

6.2.3. Activity 3: Construction of return water dams

Identified aspects and associated impacts related to the construction and operation of four proposed return water dams include the following:

- Currently none of the four return water dam footprints overlap with delineated wetlands or recommended wetland buffers (Figure 9). Hence no soil excavation and vegetation clearing works in return water dam footprint areas will result in permanent wetland habitat loss (Table 22). This impact is therefore not measurable at present, but can change should changes be made to the current infrastructure layout that could result in overlap created between return water dams and buffered wetland habitat (Figure 9).
- Release of water received from the TSF during high rainfall events (once the new return water dams reach their capacity), will result in the pollution of downstream surface water resources (wetlands). Currently two wetlands are located downstream of the proposed return water dams, namely unchannelled valley bottom 1 and channelled valley bottom 2. The current footprint area of the four return water dams are therefore located in the catchment of both of these wetlands (Figure 9).
- Seepage from the proposed return water dams containing water received from the TSF can result in the pollution of surrounding surface water resources (wetlands), which currently include unchannelled valley bottom wetland 1 and channelled valley bottom wetland 2 (Figure 9).
- Refuelling of machinery during construction can result in the spillage and/or inflow of hydrocarbons into wetlands. This is a general impact that can affect all of the delineated wetlands, including those located within close proximity to the return water dams (Figure 9).
- Movement of heavy motorised vehicles (HMVs) in wetlands will compact soils and along with other soil disturbances (see above), create an opportunity for the establishment of alien species. This is a general impact that can affect all of the delineated wetlands, including those located within close proximity to the return water dams (Figure 9).

The implementation of recommended impact avoidance and mitigation measures listed below will result in risk classes that range from the upper limit of the Low class (significance score 55) to the middle range of the Low class (significance score 27), (Tables 32 and 34). The recommended impact avoidance and mitigation measures include the following:

- The four return water dam footprint areas should continue to be located outside of delineated wetlands and their recommended buffers (Figure 9; Table 22). Changes that may be made to the layout of return water dams as a result of recommendations from other specialist studies, should ensure that no new overlap with delineated wetlands and their buffers are created (Figure 9).
- Any spillway or emergency decant structures associated with the return water dams should not release flow with a suspected low water quality into the catchment of unchannelled valley bottom wetland 1, but only into the catchment of channelled valley bottom wetland 2. Channelled valley bottom 2 is already impacted by low quality water input from the existing TSF. Unchannelled valley bottom wetland 1 is in an Unmodified condition (category A PES) and currently contains no pollution due to low quality water inputs, while channelled valley bottom wetland 2 has a Largely/Seriously modified PES (Figure 8). It is therefore recommended that the four return water dams should be moved to only overlap with the catchment area of channelled valley bottom wetland 2 (Figure 9).

Table 31: Impact assessment table for identifed wetland impacts associated with the proposed return water dams during the construction phase, without mitigation.

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of	Frequency of	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Construction phase	Construction and operation of return water dams	Release of water received from the TSF during high rainfall events (once return water dams reach capacity).	Pollution of surface water resources (wetlands) due to water released and/or seepage from return water dams during the operational phase; Pollution of surface water resources due to the spillage of hydrocarbons during the construction phase; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species in wetland areas	5	5	3	4	4.25	1	4	9.3	2	4	5	2	13	120	**M**	60	Refer to Section 6.2.3.	
		Seepage from return water dams containing water received from the TSF		4	5	3	3	3.75	1	4	8.8	4	5	5	1	15	131	**M**	60		
		Refuelling of machinery in or adjacent to wetlands during the construction phase.		1	5	3	3	3	1	2	6.0	3	3	5	2	13	78	**M**	70		
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	4	2	2.5	1	2	5.5	3	3	5	1	12	66	**M**	60		

Table 32: Impact assessment table for identifed wetland impacts associated with the proposed proposed return water dams during the construction phase, with mitigation. This also represents the risk matrix impact table for the assessments of project-related Section 21 (c) and (i) water uses associated with the proposed return water dams during it's construction phase, as per the the DWS risk assemssnt protocol (GN 509).

Phase	**Activity**	**Aspect**	**Impact**	**Flow Regime**	**Physico & Chemical**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**	**Frequency of activity**	**Frequency of impact**	**Legal Issues**	**Detection**	**Likelihood**	**Significance**	**Risk Rating**	**Confidence level**	**Control Measures**	**Borderline LOW MODERATE Rating Classes**
Construction phase	Construction of return water dams	Release of water received from the TSF during high rainfall events (once return water dams reach capacity).	Pollution of surface water resources (wetlands) due to water released and/or seepage from return water dams; Pollution of surface water resources due to the spillage of hydrocarbons during the construction phase; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species in wetland areas	3	3	3	3	3	1	1	5.0	1	3	5	2	11	55	**L**	60	Refer to Section 6.2.3.	
		Seepage from return water dams containing water received from the TSF		2	2	2	2	2	1	2	5.0	2	2	5	1	10	50	**L**	60		
		Refuelling of machinery in or adjacent to wetlands during the construction phase.		1	1	1	1	1	1	1	3.0	1	1	5	2	9	27	**L**	80		
		Movement of heavy motorised vehicles (HMVs) in wetlands		2	2	2	2	2	1	1	4.0	3	3	5	1	12	48	**L**	70		

Table 33: Impact assessment table for identifed wetland impacts associated with the proposed proposed return water dams during the operational phase, without mitigation.

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Operational phase	Operation of return water dams	Release of water received from the TSF during high rainfall events (once return water dams reach capacity).	Pollution of surface water resources (wetlands) due to water released and/or seepage from return water dams during the operational phase;	5	5	3	4	4.25	1	4	9.3	2	4	5	2	13	120	**M**	60	Refer to Section 6.2.3.	
		Seepage from return water dams containing water received from the TSF		4	5	3	3	3.75	1	4	8.8	4	5	5	1	15	131	**M**	60		

Table 34: Impact assessment table for identifed wetland impacts associated with the proposed proposed return water dams during the operational phase, with mitigation. This also represents the risk matrix impact table for the assessments of project-related Section 21 (c) and (i) water uses associated with the proposed return water dams during it's operational phase, as per the the DWS risk assemssnt protocol (GN 509).

Phase	Activity	Aspect	Impact	Flow Regime	Physico & Chemical	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures	Borderline LOW MODERATE Rating Classes
Operational phase	Operation of return water dams	Release of water received from the TSF during high rainfall events (once return water dams reach capacity).	Pollution of surface water resources (wetlands) due to water released and/or seepage from return water dams during the operational phase;	3	3	3	3	3	1	1	5.0	1	3	5	2	11	55	**L**	60	Refer to Section 6.2.3.	
		Seepage from return water dams containing water received from the TSF		2	2	2	2	2	1	2	5.0	2	2	5	1	10	50	**L**	60		

- Refer to section 6.2.1. regarding a description of mitigation measures to address impacts associated with refuelling in wetlands, unauthorised driving in wetlands, the construction of temporary structures, the layout of permanent roads, and the development of a site specific alien control and rehabilitation plan.

6.2.4. Closure/Decommissioning/Remnant impact assessment

No detail was available during the conduction of this study as to the exact processes and schedules that will be followed during closure/decommissioning. No detailed closure impact assessment could therefore be completed. This should be assessed and described in detail as part of the closure and rehabilitation plan for the mine. It is strongly recommended that rehabilitation should be carried out in an ongoing manner and not deferred to the end of the 'life of mine'. For example, whereas the rehabilitation on the TSF footprints and Storm Water Dams can only be carried out at the end of the 'life of mine', the Borrow Areas should be rehabilitated as soon as the required material has been removed from the Borrow Areas at the end of the construction phase. Remnant impacts can also not be predicted, as it is dependent on the effectiveness of recommended mitigation measures, which include impact avoidance. The use of the recommended monitoring approach would help to identify impact and rectifying them promptly to help prevent remnant impacts from developing (Section 7). Though rehabilitation cannot restore permanently transformed wetland areas that overlap with infrastructure to their pre-construction state, the objective of rehabilitation should be to address impacts that can be reversed/repaired, such as erosion features and sedimentation impacts as well as the control of alien plants in wetlands and their buffers.

6.2.5. Cumulative impact assessment

The construction of the existing 564ha Kareerand TSF in 2010 led to the destruction (permanent loss) of 35 ha of valley-bottom wetland and associated hillslope seep wetland habitats comprising the approximately 1.3km long uppermost reach of the Karreerand Stream. In addition, the construction of the existing 564ha Kareerand TSF has led to ongoing wetland impacts due to seepage and runoff of polluted water and dust emissions and from the existing TSF into surrounding wetlands, particularly channelled valley bottom wetland 2. The remaining ca. 4.km reach of the Kareerand Stream (channelled valley bottom wetland 2) situated between the TSF and its confluence with the Vaal River has been particularly severely impacted by reduced water quality, sedimentation and soil contamination resulting from seepage and controlled runoff and spills from the existing TSF.

The principal cumulative impacts to wetland watercourse which are envisaged to result for the proposed Kareerand TSF Extension project, based on the current development layout, are briefly listed below (Table 22):

- A combined wetland area of 11. 65 ha that overlaps with the proposed TSF expansion areas. This includes 10.03 ha of natural wetland habitat (channelled valley bottom wetland 2 and seep wetland 3) and 1.62 ha of artificial wetland habitat (artificial wetlands 4 and 5).
- A combined natural wetland area of 11.87 ha that overlaps with two of the proposed burrow pits.

7. PROPOSED WETLAND MONITORING APPROACH AND BASIC DATASHEET

Prior to the start of the construction phase wetland data can be collected in the format present here, preferably during the growing season (Table 26). Data fields can be used, refined and adjusted to suit the needs of a particular wetland depending on its location and impact. The table can be updated at quarterly or biannual intervals during the construction phase (Table 26). It is, however, important to obtain reliable baseline information for all affected wetlands in the study area prior to the onset of construction activities.

An approach where a list of specific wetland features and impacts are systematically recorded and described to generate data during the construction process, is regarded to be of more value, compared to specifying that a PES technique, such as WET-Health Level 1 (Macfarlane *et al.*, 2008) or another PES associated method, is used to monitor wetlands. In the experience of the author the use of a PES technique for wetland monitoring is too subjective and robust to provide useful baseline data that has consistently been captured for each wetland.

Interpretations from systematically recorded data fields that have specifically been selected based on the expected impacts of the proposed project are therefore more useful, as they provide site specific information that indicate how a particular wetland has been impacted during the construction phase and which impacts (i.e. remnant impacts) should be addressed during the rehabilitation phase (Table 26). Changes to the data sheet format can be made as required, while captured data can also be used to determine the PES of a particular wetland through the use of an applicable PES method.

The proposed data capturing sheet does not incorporate water quality and groundwater aspects related to delineated wetlands. Water quality and groundwater features are assumed to form part of separate monitoring processes, should it be deemed necessary. Diatom assessments may not be practically feasible at all times in all wetlands due to the inconsistent and/or insufficient presence of surface water. Bi-annual diatom sampling is, however, recommended in channelled valley bottom HGM unit 2 where water is expected to be present throughout the year due to seepage from the existing TSF. The proposed basic monitoring datasheet can be used for monitoring and as part of an action plan to direct intervention once impacts are recorded (Table 26).

Table 35: Proposed basic wetland monitoring datasheet that can be amended as need be.

<table>
<tr><td>Wetland name:</td><td>Assessment date (include year):</td><td>Monitoring interval (e.g. first, second, third, etc.)</td></tr>
<tr><td>Name of assessor(s):</td><td>Wetland fixed point photo coordinates:</td><td>Photo numbers:</td></tr>
<tr><td>HGM wetland unit type and number:</td><td>Baseline PES category</td><td>Baseline EIS category</td></tr>
<tr><td>Channel width (bankfull) where present:</td><td>Channel depth (bankfull) where present:</td><td>Dominant bed material (e.g. bedrock, boulder, gravel, sand, silt/clay):</td></tr>
<tr><td rowspan="2">Presence of scour or headcut erosion features in the wetland and wetland buffer (record coordinates with GPS and take photos):</td><td colspan="2">Dominant upstream catchment land uses:</td></tr>
<tr><td colspan="2">Presence, position (GPS coordinates) and thickness of recorded sediment depositions, specifically tailings material, in the wetland (record a minimum of three points along the length of the wetland in systems where tailings material or other sediment depositions are present):</td></tr>
<tr><td>Width and depth of recorded headcut and scour features :</td><td colspan="2">Creation of new channels, or channel incision and widening in existing channels in the wetland and wetland buffer (record coordinates with GPS and take photos):</td></tr>
<tr><td colspan="3">Wetland and wetland buffer vegetation description (e.g. number of vegetation strata, strata height and canopy cover of each vegetation strata, as well as the names of dominant and common trees, shrubs, forbs and grasses):</td></tr>
</table>

Identification and cover abundance rating (e.g. rare, uncommon, common, sub-dominant and dominant) of alien plant species recorded in the wetland		
Alien tree and shrub species	Alien grass species	Alien forb and sedge species
Presence of stockpiles within the wetland or its buffer	Record the presence of any waste material that may be present in the wetland or buffer.	Record signs of recent erosion and sedimentation from stockpiles or other sediment sources (investigate silt fences and other stabilisation measures):
Has the wetland recently experienced a burn (fire) event	Are unauthorised vehicle tracks present in the wetland or buffer (take photos of new tracks)	Are removed topsoil stockpiles stable and separated from subsoil stockpiles?
General notes on other impacts, as well as the presence and effectiveness of mitigation measures:		

8. SUMMARY AND CONCLUSION

8.1. Introduction

Imperata Consulting CC was subcontracted by De Castro and Brits Ecological Consultants CC to conduct a baseline wetland delineation and assessment study for the proposed extension of the existing Kareerand Tailings Storage Facility (TSF), southeast of Stilfontein in North West Province. This wetland study forms part of an environmental authorisation process that will incorporate several different specialist studies. This study area forms part of AngloGold Ashanti's (AGA) Mine Waste Solutions (MWS) property.

MWS has identified that the optimum strategy for creating additional TSF capacity is to construct an extension of the existing 564 ha Kareerand TSF whilst at the same time increasing the final design height of the existing footprint. These activities will form part of the Kareerand TFS Extension Project. The extension is proposed to be constructed to the north-west of the existing TSF footprint and the extension footprint will be approximately 382.6 ha in extent and will abut onto the existing footprint (Figure 1). Due to the increase surface area of the extended TSF there will be additional return water dams (Figure 1) to control run off from the extended TSF. Potential borrow areas (borrow pits) for extraction of soils for use in stabilising the retaining walls of the TSF extension are also included in this project (see Figure 1).

This report assesses the presence, type and ecological condition of wetlands within the demarcated study area and surrounding 500 m study area buffer (Figure 1), along with potential impacts of proposed new mining infrastructure features on delineated wetlands. The study area and proposed new mining infrastructure features can be summarised as follow (Figure 1):

- Study area = 1495.5 ha
- Study area with surrounding 500 m buffer = 2793.7 ha
- Existing Kareerand tailing storage facility (TSF) = 564 ha
- Proposed TSF extension within the study area = 382.6 ha
- Combined Kareerand TSF with the new TSF extension included = 946.6 ha
- Burrow pits (three in total) = 666.3 ha
- Return water dams (four in total) = 43.2 ha

8.2. Terms of Reference and Approach

Terms of references associated with the specialist wetland assessment include the following for the study area as defined in Section 1 (Figure 1):
Terms of references associated with the specialist watercourse investigation include the following for the study area as defined in Section 1 (Figure 1):

- Desktop analyses and literature review of existing wetland-related information, including available recent and historic aerial imagery.
- A field survey by a Pr.Sci.Nat. registered ecologist that will investigate, delineate and describe wetlands according to the field procedure developed by the DWS (DWAF 2005; DWAF 2008).
- A classification of identified wetland areas into appropiate hydro-geomorphic units according to the National Wetland Classification System for South Africa

(Ollis *e al.*, 2013).

- Assessments of the Present Ecological State (PES) and the Ecological Importance and Sensitivity (EIS) of delineated wetlands according to the applicable methods developed by either the Department of Water and Sanitation (DWS) or the Water Research Commission (WRC), (DWAF 1999; DWAF 2007; Macfarlane *et al.,* 2008; Rountree & Malan 2013). The accuracy and level of confidence of these assessments will be improved through a wet season survey (approximately November to May) rather than a dry season survey.
- Assessment of ecosystem services associated with identified wetlands will also be determined with the EIS method described by Rountree and Malan (2013).
- Surrounding wetland areas located in a 500m radius around the proposed footprints will be delineated at a secondary level of detail through limited site sampling and a stronger desktop approach (Figure 1). Wetlands located within a 500 m radius around proposed Section 21 (*c*) and (*i*) water uses form part of the regulated area for which authorisation have to be obtained from the DWS, either as a General Authorisation (GA) or a full Water Use License (WUL), (DWAF, 2009).
- Creation of wetland sensitivity maps and associated GIS shapefiles.
- Undertaking a Risk assessment protocol with associated matrix for expected project-related impacts that may affect identified wetland systems, based on the impact assessment method published in GN 509 (published 26 August 2016).
- Provision of recommended impact mitigation measures related to the proposed development. This includes the recommendation of site specific wetland buffers that take into consideration the guideline document for the determination of wetland buffer zones (Macfarlane *et al.* 2015).
- Performing a risk assessment protocol with associated matrix for expected project-related Section 21 (c) and (i) water uses that may affect identified wetland systems. The risk matrix assessment will be based on the method published in GN 509 (26 August 2016), as well as available information regarding proposed mining activities and infrastructure.

Limitations associated with this study include the following:

- Wetland areas within transformed landscapes, such as previously cultivated lands or mining areas with existing infrastructure, are often affected by disturbances that restrict the use of available wetland indicators, such as hydrophytic vegetation or soil indicators (e.g. as a result of the dominance of alien vegetation, stock piling, sedimentation, hard surfaces, and infilling).
- The survey was conducted during a single survey in early November and had experienced very low rainfall in the early growing season prior the survey (pers. comm. Mr Gunther Wiegenhagen[2]). The majority of the area was also very heavily grazed at the time of the field survey. The difficulty of identifying wetland plant species was therefore greatly increased and some species were in an unidentifiable state.

8.3. Description of the Study Area

The proposed infrastructure footprints included in the study area is situated directly adjacent to the northern boundary of the current Mine Waste Solution surface rights area on portions of

[2] Mr Gunther Wiegenhagen is a Senior Environmental Coordinator Biodiversity and Closure Planning at Anglo Gold Ashanti.

the farms Buffelsfontein 443 IP, Hartebeestfontein 442 IP, Megadam 574 IP, Kareerand 444 IP and finally Kromdraai 420 IP in the east.

Construction of the existing Kareerand TSF only started in 2011. There is little existing infrastructure within the study area itself. Existing infrastructure comprises a guard house, a pipeline, a small laydown area and engineered dirt roads associated with the existing TSF, as well as farming related infrastructure such as dirt tracks, a small cement reservoir adjacent to the small endorheic pan and two abandoned farm homesteads in the eastern parts of the study area on the farms Kromdraai and Kareerand. Three recently abandoned (ca. 6 years ago), centre pivot irrigation fields are also present in the eastern parts of the farm Kromdraai.

The study area and its 500 m buffer is located within the Vaal Water Management Area (WMA). Previously, before the combination of the Vaal WMA into a single primary catchment, the division between the Middle Vaal and Upper Vaal WMAs transected the study area in a western and eastern section. The Ecoregion Classification for South African Rivers indicates that the study area forms part of the Highveld (11) category.

Three quaternary catchments overlap with the study area, namely C24A with a narrow sliver of the study area in the western-most section, C24B with the central and largest portion of the study area and C23L with the eastern section. All three of the quaternary catchments are 'largely modified' (category D Present Ecological State), while their Ecological Importance and Sensitivity (EIS) categories range from high to moderate (Middleton and Bailey, 2008). The mean annual precipitation (MAP) for the quaternary catchments range between 584-619 mm, while the mean annual evaporation (MAE) range between 1700-1750 mm.

According to the NWBSP 2015, the Ecosystem threat status of two of the vegetation types occurring within the study area is as follows:

- Vaal Reefs Dolomite Sinkhole Woodland (**Not Currently Threatened**).
- Rand Highveld Grassland (**Endangered**).

8.4. Results

The November site survey confirmed the presence of wetland habitat within the study area and along headwater drainage lines indicated on topographical map 2626DD. Recorded wetland indicators included hydromorphic features, such as gleying, low chroma matrix colours, spots of iron depletion and mottling, while hydrophyte (DWAF, 2005 & 2008) and hygrophyte (Retief & Herman, 1997) species were also identified. Natural wetlands were classified into four different types of hydro-geomorphic (HGM) units, while identified man-made wetlands were classified as artificial systems (Figure 9; Table 26):

- 3 x Unchannelled valley bottom wetlands
- 2 x Channelled valley bottom wetlands
- 2 x Seep wetlands
- 1 x Pan (depression) wetland
- 2 x Artificial wetlands

All three valley bottom wetlands present within the study area, remain unchannelled within the study area boundary (wetlands 1, 2 and 6). Both valley bottom wetlands 2 and 6 become weakly channelled downstream of the study area. Their channel features do become better defined closer to their confluences with the Vaal River. Each of the five identified valley bottom wetlands form tributaries of the Vaal River, with wetlands 2 and 6 classified as channelled valley bottom wetlands. Recorded hydromorphic indicators included distinct signs of gleying and G-horizons in the top soil profile in the centre of valley bottom wetlands (Figure 4). The outer wetland margins were often less clayey and contained mottles surrounded by areas of iron depletion, which were also indicative of wetland conditions (Figure 4; DWAF 2005 and 2008).

Two seep wetlands were identified and occur within the study area. Seep wetland 3 is located upstream of channelled valley bottom wetland 2, while seep wetland 7 is located directly upstream of unchannelled valley bottom wetland 8 (Figure 9). Hydromorphic indicators recorded in seep wetland 3 included the presence of a G horizon with signs of gleying at a depth of approximately 0.3 m, in the centre of the upstream portion of the wetland (Figure 6). Seepage from the toe of the existing TSF into the wetland was also recorded along the remaining eastern edge of the wetland that borders the encroached TSF

Two small artificial wetlands with a combined size of 2.53 ha were identified immediately west of the existing TSF in an area where no evidence of pre-development wetlands were found, as interpreted from historical aerial imagery. Seepage along the western boundary from the TSF is expected to be responsible for the formation of artificial wetlands 4 and 5 with a characteristic long narrow zone dominated by patches of the obligate hydrophyte *Typha capensis*. Time series imagery indicated no signs of elongated and dense patches of *T. capensis* along the western boundary of the TSF, prior to the operation of the facility.

A single small pan wetland of 0.72 ha was identified in the north-western portion of the study area. The delineated pan includes a central zone, which forms the largest portion of the wetland and a narrow peripheral zone around it of approximately 3-4 m wide. A small seep is connected to the pan is situated immediately to the north of the pan. The seep is small enough to have been delineated as part of the pan and is also located within the pan basin. The pan is underlain by ferricrete, or hard plintic horizon, which is exposed on the surface in areas. The shallow ferricrete layer is expected to form an impermeable or semi-impermeable aquitard that cyclically creates saturated soil conditions followed by surface ponding after sufficient rainfall. The pan can be best described as an ephemeral pan that can be dry for several months at a time followed by periodic inundation.

Present Ecological State (PES) categories of assessed wetlands range from ‘Unmodified’ (category A) to 'Seriously modified' (category E), (Table 36). Ecological Importance Sensitivity (EIS) categories of assessed wetlands range from High (category B) to Low/Marginal (category D), (Table 36).

Hydro-functional and direct human benefits associated with delineated wetlands range between class D (Low/Marginal) to class E (None), with the exception of water quality enhancement performed by channelled valley bottom wetland 2, which is High (class B). This pertains specifically to the opportunity and ability of remaining habitat in channelled valley bottom wetland 2 to trap tailings through sedimentation in areas that remain well vegetated.

Table 36: Summarises results from the wetland assessment study and indicates identified wetland types, wetland sizes; assessed PES and EIS categories; overlap between delineated wetlands in proposed infrastructure footprints, and overlap between recommended wetlands buffers (80 m, 100 m and 200 m buffers) and proposed infrastructure footprints (also refer to Figure 9).

Wetland Number	Wetland Type	PES	EIS	Surface area in study area and 500m buffer	Surface area in study area only	Overlap with TSF Extension	Overlap with burrow pits	Overlap with return water dams	Recommended buffer width	Buffer overlap with proposed infrastructure footprints
1	Unchannelled valley bottom wetland	**A**	**B**	13.26 ha	1.90 ha	-	1.35 ha	-	100 m	-
2	Channelled valley bottom wetland	**D/E**	**C**	28.94 ha	6.02 ha	3.76 ha	-	-	80 m	13.11 ha (TSF Extension)
3	Seep wetland	**E**	**D**	6.27 ha	6.27 ha	6.27 ha	-	-	-	-
4	Artificial wetland	**N/A**[3]	**E**	1.52 ha	1.52 ha	1.52 ha	-	-	-	-
5	Artificial wetland	**N/A**	**E**	1.01 ha	0.67 ha	0.10 ha	-	-	-	-
6	Channelled valley bottom wetland	**C**	**C**	15.02 ha	9.30 ha	-	7.82 ha	-	100 m	27.97 ha (burrow pits)
7	Seep wetland	**D**	**D**	6.80 ha	6.80 ha	-	2.70 ha	-	100 m	
8	Unchannelled valley bottom wetland	**C**	**C**	2.42 ha	-	-	-	-	100 m	-
9	Unchannelled valley bottom wetland	**C**	**C**	9.20 ha	-	-	-	-	-	-
10	Pan wetland	**B**	**B**	0.72 ha	0.72 ha	-	-	-	200 m preliminary minimum buffer	2.86 ha (burrow pit)
Total				**85.17 ha**	**33.21 ha**	**11.65 ha**	**11.87 ha**	**-**	**-**	**43.87 ha**

[3] N/A (not applicable) refers to artificial wetlands that don't have a PES category assigned to them as they existed as terrestrial areas prior to the development of increased soil moisture conditions due to man-made activities.

8.5. Proposed Infrastructure Footprints, Wetlands, Buffers and Layout Considerations

All of the delineated wetlands illustrated in Figure 9 are habitats that are protected by national environmental legislation, as they are regarded as watercourses that are defined in the National Water Act (Act 36 of 1998) (NWA). This includes both natural and artificial wetlands. Various listed activities stipulated in the National Environmental Management Act (NEMA), Act No. 107 of 1998 and the EIA Regulations of 2014, pertain to wetlands and other watercourse for which environmental authorization will be required.

Wetlands and other watercourses are protected water resources in the National Water Act (NWA), Act 36 of 1998. Development within wetlands is regarded as a water use, which can only be allowed through an approved Water Use License, irrespective of the condition of the affected watercourse. Section 21 of the NWA defines different types of water use in a watercourse. Water uses activities associated with wetland and riparian stream typically include the following:

(c) impeding or diverting the flow of water in a watercourse
(i) altering the bed, banks, course or characteristics of a watercourse.

Any wetland located within a 500 m radius of Section 21 (c) and (i) water uses associated with the project requires either a full Water Use License Application or a General Authorisation (GA) in order to have authorisation from the Department of Water and Sanitation (DWS).
GN 509 (August 2016) provides a risk matrix protocol to determine the impact significance and risk class for project aspects that are associated with Section 21 (c) and (i) water uses. A GA can be applied for to the DWS in the event that all of the assessed aspects and related impacts have a Low risk after mitigation (GN 509). If any one of the impacts have a Moderate or High risk class, a full WULA needs to be undertaken.

Information obtained from the wetland study should firstly be used to create an environmentally sensitive layout design that avoids wetland impacts as far as possible by locating infrastructure features away from delineated wetlands as illustrated in Figure 9. Part of this process of impact avoidance, which is regarded as the primary means of impact mitigation, involves the demarcation of a setback area, or a buffer, which consists of terrestrial habitat located between the outer edge of the watercourse and the start of the development footprint. The buffer zone tool for the determination of aquatic impact buffers and additional set-back requirements for wetland ecosystems (Macfarlane *et al*, 2014) was used to assist in the development of recommended buffers. Different buffers were evaluated for different mining-associated land uses, such as proposed excavation activities (i.e. burrow pits and return water dams) and proposed mining waste storage facilities (i.e. return water dams and the TSF expansion area). This was done based on available information, which excluded any hydro-pedological evaluation of water movement properties in wetland and upslope terrestrial soils.

A 100 m wide buffer is recommended for the following wetlands located within a 100 m radius of the study area (Figure 9; Table 36):

- Unchannelled valley bottom wetlands 1 and 8
- Channelled valley bottom wetland 6
- Seep wetland 7

An 80 m wide buffer is recommended for channelled valley bottom wetland 2 around the proposed TSF expansion area, while a preliminary 200 m minimum buffer is recommended for pan wetland 10 in order to protect the endorheic pan and its catchment (Figure 9; Table 36).

Seep wetland 3, along with artificial wetlands 4 and 5, are regarded as the wetlands with the lowest EIS, lowest PES, and lowest value in terms of hydro-functional importance and provision of direct human benefits in the study area (Section 5.2). The long-term management of artificial wetlands adjacent to the TSF is problematic as they are expected to deteriorate further over time due their increasing salinity from continued seepage out of tailings materials. Improved mitigation measures to help reduced seepage from the TSF and its existing return water dams may result in the gradual disappearance of the artificial wetlands over time.

Changes to the layout design of proposed burrow pits and return water dams are expected to be easier compared to the proposed expansion footprint of the TSF, as the expansion area needs to adjoin the existing TSF facility. Avoiding overlap between the TSF and channelled valley bottom wetland 2 and its recommended 80 m buffer, is regarded as the top avoidance priority with regards to layout change recommendations for the TSF expansion area (Figure 9). This is due to the strategic importance of channelled valley bottom wetland 2, which provides connectivity between the TSF and the Vaal River, and also functions as the primary sink for tailing materials that become mobilised and move from the TSF. It follows that overlap between the expansion area of the TSF and other wetlands that border the existing TSF, such as seep wetland 3 and artificial wetlands 4 and 5, may not be avoidable (Figure 9; Table 36). The use of buffers around these wetlands are therefore currently constrained as it is assumed that impact avoidance is an unlikely means of mitigation due to the impracticality thereof in this instance. The current layout design of the proposed infrastructure footprints will result in a complete and permanent loss of seep wetland 3 and artificial wetland 4, while approximately 10 % of artificial wetland 5 could also be destroyed. Artificial wetland 5 will be protected as part of the 80 m buffer around channelled valley bottom wetland 2 (Figure 9).

It is recommended that the project proponents should also investigate the possibility of avoiding overlap between these three wetlands and the proposed TSF expansion area. Layout alternatives that should be considered include moving the TSF expansion area east and southeast, outside of the current study area, which will be dependent on the absence of other sensitive biophysical features in the area, including unknown wetlands. Further encroachment of the TSF into the upstream portion of unchannelled valley bottom 9, located outside of the current study area should be avoided (Figure 9). Unchannelled valley bottom 9 extends beyond its delineated boundaries, which includes the area upstream of the 500 m study area buffer. The existing TSF footprint already partially overlaps with the wetland and should therefore not be expanded further south or in a south-western direction.

8.6. Risk Matrix Assessment and Recommended Mitigation Measures

Results from the impact assessment for the construction and operational phases of the project are provided in Tables 37 and 38. The impact risk assessment tables pertains specifically to Section 21 (*c*) and (*i*) water uses, as defined in the National Water Act (Act No. 36 of 1998) (NWA), which include:

(c) Impeding or diverting the flow of water in a watercourse
(i) Altering the bed, banks, course or characteristics of a watercourse

The DWS developed risk assessment protocol to assess impacts related to Section 21 (c) and (i) activities is encompassing and was modified to assess the full range of potential project-related impacts that can affect identified wetlands, with and without mitigation. It is therefore also used as an impact assessment method that can be applied to the EIA phase.

Results from the Risk assessment protocol with associated matrixes for expected project-related impacts, based on the impact assessment method published in GN 509 (26 August 2016), refers solely to the 'with mitigation' scenario, meaning that it assumes all of the recommended mitigation measures, including impact avoidance recommendations, will be implemented. These results are indicated in Tables 24, 26, 28, 30, 32 and 34.

It is important to note that the impact assessment as provided in Tables 23 to 34 will change in the event that recommended impact avoidance measures related to changes in the current infrastructure layout design, as described in Section 6.1, cannot be implemented for whatever reason. Changes to the proposed infrastructure footprints or the inability to implement other recommended mitigation measures will therefore require a re-evaluation of assessed impacts and can result in a change in impact rating categories. Identified impacts and their recommended mitigation measures are discussed below and assesses all delineated wetlands collectively as a single group, with the result that the worst (highest) impact affecting any of the wetlands will be reflected. This pertains specifically to the encroachment of the proposed TSF expansion area into seep wetland 3 and artificial wetlands 4 and 5, for which avoidance as a form of impact mitigation may not be possible. No information was available about proposed linear infrastructure features at the time of report writing.

Table 37: Summary of the impact assessment results (risk) for the all of the proposed development features for the construction phase, with and without mitigationmitigation.

Activity	**Aspect**	**Impact**	**Risk without mitigation**	**Risk with mitigation**	**Amended Risk Rating**
Expansion of TSF	Infrastructure encroachment into wetland habitat	Permanent loss of wetland habitat due to infrastructure encroachment; Sedimentation of tailings material in wetlands; Pollution of surface water resources (wetlands) due to received seepage from the TSF and spillage of hydrocarbons during construction; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species in wetland areas	**H**	**H**	
	Tailings material transported with runoff		**M**	**M**	**L**
	Seepage from new TSF extension into wetland habitat		**M**	**M**	**L**
	Refuelling of machinery during construction in or near wetlands		**M**	**L**	
	Movement of heavy motorised vehicles (HMVs) in wetlands		**M**	**L**	
Excavation of burrow pits	Soil excavation in burrow pit footprints that overlap with wetlands	Permanent loss of wetland habitat; Desiccation of wetland habitat due to modified hydrology, including surface inflows and drawdown of groundwater level into excavated areas upslope of wetlands; Loss of wetland vegetation and modification of wetland topography; Deposition	**H**	**L**	
	Soil excavation works in burrow pit footprints located upslope and in close proximity to wetlands		**M**	**L**	
	Stockpiling of excavated soil and subsoil material in wetlands		**M**	**L**	

Activity	Aspect	Impact	Risk without mitigation	Risk with mitigation	Amended Risk Rating
	Runoff from bare and unprotected stockpiles in/or adjacent to wetlands	of ex situ soil material on wetland habitat (smothering of vegetation); Pollution of surface water resources (wetlands) due to spillage of hydrocarbons during construction; Compaction of wetland soils; Encroachment of alien species into wetland habitat.	M	L	
	Refuelling of machinery during construction in or near wetlands		M	L	
	Movement of heavy motorised vehicles (HMVs) in wetlands		M	L	
Construction return water dams	Release of water received from the TSF during high rainfall events (once return water dams reach capacity).	Pollution of surface water resources (wetlands) due to water released and/or seepage from return water dams during the operational phase; Pollution of surface water resources due to the spillage of hydrocarbons during the construction phase; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species in wetland areas	M	L	
	Seepage from return water dams containing water received from the TSF		M	L	
	Refuelling of machinery during construction		M	L	
	Movement of heavy motorised vehicles (HMVs)		M	L	

Table 38: Summary of the impact assessment results (risk) for the all of the proposed development features for the operational phase, with and without mitigationmitigation.

Activity	Aspect	Impact	Risk without mitigation	Risk with mitigation	Amended Risk Rating
Operation of the expanded TSF	Tailings material transported with runoff	Sedimentation of tailings material in wetlands; Pollution of surface water resources (wetlands) due to received seepage from the TSF; Compaction of wetland soils due to the movement of HMVs; Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species into wetland areas.	M	M	L
	Seepage from new TSF extension into wetland habitat		M	M	L
	Movement of heavy motorised vehicles (HMVs) in wetlands		M	L	

Activity	Aspect	Impact	Risk without mitigation	Risk with mitigation	Amended Risk Rating
Open burrow pits	Soil excavation works in burrow pit footprints located upslope and in close proximity to wetlands	Desiccation of wetland habitat due to modified hydrology, including surface inflows and drawdown of groundwater level into excavated areas upslope of wetlands; Deposition of ex situ soil material on wetland vegetation (smothering of vegetation); Compaction of wetland soils due to the movement of HMVs; Encroachment of alien species into wetland habitat.	M	L	
	Stockpiling of excavated soil and subsoil material in wetlands		M	L	
	Runoff from bare and unprotected stockpiles in/or adjacent to wetlands		M	L	
	Movement of heavy motorised vehicles (HMVs) in wetlands		M	L	
Operation of return water dams	Release of water received from the TSF during high rainfall events (once return water dams reach capacity).	Pollution of surface water resources (wetlands) due to water released and/or seepage from return water dams during the operational phase;	M	L	
	Seepage from return water dams containing water received from the TSF		M	L	
			M	L	
			M	L	

Tables 37 and 28 indicate that the risk classes range from Low to High Risk with mitigation during the construction phase and from Medium to Low during the operational phase. The assessed project infrastructure layout will only have one impact component with a High risk with mitigation, namely permanent wetland habitat loss due to TSF infrastructure encroachment (Tables 24, 37 and 38). The total natural habitat wetland loss will be 10.03 ha, while 1.62 ha of artificial wetland habitat will also be lost (Table 36). This impact appears to be largely unavoidable due to the location of the existing TSF footprint that already overlaps with wetland habitat.

Wetland impacts associated with tailings transported with runoff and deposited in wetland habitat, as well as low water quality inputs caused by seepage from the extended TSF, can be amended to have a Low Risk, on the condition that specific mitigation measures are adhered to as provided in the risk matrix protocol (GN 509):

- **Implementation of the 80 m setback area (buffer) between channelled valley bottom wetland 2 and the proposed TSF extension area.**
- **Maintenance of the 80 m buffer to keep it functional by ensuring that it is well vegetated and free of alien plant species.**
- **Construction of a containment berm around the TSF expansion area to help avoid tailings transported via runoff into downstream watercourses.**
- **Containment structures of a sufficient size should be designed, implemented and maintained to remove tailing material from runoff during high rainfall or**

persistent rainfall events at outflow/overflow structures in the TSF expansion footprint. Provision should be made to incorporate water volumes associated with 1:50 and 1:100 year flood events.

- **The existing in-channel dam in channelled valley bottom wetland 2 located at coordinates 26°54'7.98"S 26°52'37.97"E, approximately 900 m south of the study area, can be utilised to help trap runoff-transported tailings. It is proposed that increased water storage capacity in the dam is created during the wet season through a pipeline and pump system that transport excess water from a predetermined water line in the dam to the proposed return water dams located toward the west or even the TSF itself (Figure 9). Tailing material that enters the upstream portion of the wetland during the wet season will be trapped more effectively in the dam, and should be periodically removed by dredging the dam and returning the tailings to the TSF.**
- **The use of an impermeable liner that covers the entire floor of the TSF expansion footprint is recommended along with a system that will intercept seepage from the toe of the TSF and return it to the centre of the TSF. Provision should be made for wetter than average years including water volumes associated with 1:50 and 1:100 year flood events.**
- **Recommendations provided in the specialist geotechnical report should also be adhered to in order to reduce the risk of seepage from the TSF into adjacent terrestrial and wetland areas.**

Conditions for applying for a GA is, however, not fulfilled due to the presence of an impact with a High risk class in spite of mitigation (Tables 10 and 24). A full WULA will therefore have to be undertaken in line with requirements from the DWS. **Provided that mitigation recommendations suggested in this report are accurately implemented, the project is not considered to contain critical fatal flaws in terms of wetland impacts and there is therefore no objection to the project from a wetland perspective**. **This is in light of the fact that wetland habitat that overlap with the proposed TSF extension is unavoidable due to the the location of the existing TSF footprint. Mitigation wil, however, be essential.**

The following summary of mitigation and impact avoidance measures are recommended in order to minimise envisaged negative impacts of the proposed project infrastructure on wetlands delineated within the study area and surrounding 500 m buffer (Figure 9):

- The proposed TSF extension should be set back at a minimum distance of 80 m around channelled valley bottom 2 to avoid overlap and reduce the risk of seepage and deposition of tailings material in the wetland.
- Prevention of overlap between the TSF expansion area, seep wetland 3 and artificial wetlands 4 is currently not expected to be possible, but should still be investigated as a potentially feasible alternative.
- The use of an impermeable liner that covers the entire floor of the TSF expansion footprint is recommended along with a system that will intercept seepage from the toe of the TSF and return it to the centre of the TSF. Provision should be made for wetter than average years, including water volumes associated with 1:50 and 1:100 year flood events. Recommendations provided in the specialist geotechnical report should also be adhered to in order to reduce the risk of seepage from the TSF into adjacent terrestrial and wetland areas.
- No refuelling or unauthorised driving should occur in delineated wetlands or their recommended buffer zones. Wetlands and buffers should be indicated on maps used during the construction phase and also clearly demarcated on site. Toolbox talks should

include discussions that will refer to mapped and onsite demarcated wetland boundaries as sensitive areas that should be avoided, unless construction work is authorised in the wetland as part of a received Record of Decision (ROD) for the EIA and issued Water Use License (WUL).

- The Master Layout Plan that forms part of the Water Use License and indicate approved infrastructure features along with buffered wetlands should be adhered to and made available to different construction crews and contractors.
- Temporary infrastructure features, such as construction roads, construction camps, laydown/stockyard areas and stockpiles should also be located outside of buffered wetlands unless authorised and indicated on the Master Layout Plan that forms part of the Water Use License Application (WULA).
- Permanent roads that will be used during the operational phase should avoid overlap with delineated wetland areas and their buffers.
- Unauthorised driving in wetlands that result in vehicle track entrenchment can be ripped using manual labour or mechanical means, depending on the magnitude of the impact.
- Development of a site specific alien control plan during the early rehabilitation phase. This plan should be developed by an experienced botanist or wetland ecologist that will map problem areas and provide species specific recommendation to addressed alien established within delineated wetlands in the study area. The alien control plan should be updated and its implementation monitored during the rehabilitation phase (starting at the end of construction) and during the operational phase of the project.
- The alien control plan can form part of a larger wetland rehabilitation plan that should be developed near the end of the construction phase to address remnant wetland impacts that were not sufficiently addressed during the construction phase.
- All burrow pits should be moved to terrestrial areas located outside of buffered wetlands, including 100 m and 200 m wetland buffers.
- The pan wetland catchment area should be determined and regarded as a sensitive area that will replace the 200 m preliminary minimum buffer, once detailed contour line information is available for the study area.
- No burrow pits are currently located close to channelled valley bottom 2, but future layout changes that may move burrow pit footprints closer should incorporate the recommended 80 m buffer and increase it in size to 100 m, as is the case for other wetlands located in close proximity to burrow pit footprints.
- Recommended buffers to protect wetlands from burrow pit excavation works are constrained by uncertainties, such as the depth of excavation activities and the hydropedological properties of wetland and upland soils. It is recommended that an opinion from a hydropedologist is obtained to help refine buffer distances between different wetlands and proposed burrow pits.
- Movement of burrow pits into the proposed TSF extension footprint can be considered, but this should not alter the permeability of material underlying the TSF expansion in an adverse manner that will increase the risk of seepage from the new TSF area into downstream wetlands. Nor should it risk the effectiveness of recommended mitigation measures, such as the proposed impermeable liner on the floor of the new TSF extension area. Input from a geohydrologists and geotechnical specialist are recommended in this regard.
- Stockpiles should be located outside of all buffered wetlands and silt fences should be erected downslope of them to capture sediment runoff during the wet season. Silt fences should be repaired and maintained for the duration of the construction phase. Additional

silt fences or silt bays should be used in the event that existing structures have insufficient capacity in spite of cleaning efforts.

- The four return water dam footprint areas should continue to be located outside of delineated wetlands and their recommended buffers. Changes that may be made to the layout of return water dams as a result of recommendations from other specialist studies, should ensure that no new overlap with delineated wetlands and their buffers are created.
- Any spillway or emergency decant structures associated with the return water dams should not release flow with a suspected low water quality into the catchment of unchannelled valley bottom wetland 1, but rather only into the catchment of channelled valley bottom wetland 2. Channelled valley bottom 2 is already impacted by low quality water input from the existing TSF. Unchannelled valley bottom wetland 1 is furthermore in an Unmodified condition (category A PES) and currently contains no pollution of low quality water inputs from the TSF, while channelled valley bottom wetland 2 has a Largely/Seriously modified PES. It is therefore recommended that the four return water dams should be moved to only overlap with the catchment area of channelled valley bottom wetland 2.
- Lastly, it is recommended that a follow-up wetland survey be undertaken later in the growing season to improve the level of confidence associated with delineated wetland boundaries, as well as PES and EIS wetland assessments. This is due to the unidentifiable state of various plant species during the November 2017 survey (Section 3.3).

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Raimondo, D., Van Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kanundi, D. & Manyana, P.A. (Eds.) 2009. Red Data Book of South African Plants. Strelitzia No. 25.

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Rountree, M.W., Malan, H. & Weston, B. (Editors). 2013. Manual for the Rapid Ecological Reserve Determination of inland wetlands (Version 2.0). Joint Department of Water Affairs/Water Research Commission study. Pretoria.

APPENDIX A: CURRICULUM VITAE - L.E.R. GROBLER

Name:	Retief Grobler	**English Fluency:**	Excellent
Discipline:	Watercourse/Wetland Assessments	**Nationality:**	South African
Education:	M.Sc	**Age:**	39
Project Position:	Wetland Ecologist	**Years' experience:**	12

School	Date of Completion	Degree/Certification
University of Pretoria	2010	M.Sc (Botany) (cum laude)
University of Pretoria	2004	B.Sc Hons (Botany) (cum laude)
University of Pretoria	2002	B.Sc (Plant Diversity and Environmental Management)

Certificates and Courses:

2009: Wetland Index of Habitat Integrity (Wetland IHI) training course presented by Mark Rountree, June 2009.

Professional Affiliation:

Registered as Professional Natural Scientist (Pr. Sci. Nat) with the South African Council for Natural Scientific Professions (SACNASP) in the fields of Botanical and Ecological Science since 2009. Registration number 400097/09, registered under Mr LER Grobler.

Career Highlights:

- Co-lecturer and founding member of a wetland short course presented with the University of Pretoria and later the University of the Free State for NGOs, government officials and consultants from 2004 to present.
- Appointed as the sole wetland specialist at Strategic Environmental Focus, an environmental consulting firm in South Africa, in January 2006.
- Formation of Imperata Consulting, a specialist wetland and watercourse consulting company, in March 2007.
- Involvement in the planning, selection and ecological assessments for the national wetland rehabilitation programme that is managed by the Working for Wetlands Programme (previously part the South African National Biodiversity Institute), under the auspices of the Department of Environmental Affairs, from 2007 to present.

- Development and implementation of a biomonitoring protocol for the pre-construction, construction and post-construction phases of the New Multi Product Pipeline (NMPP) for Transnet, a State Owned Enterprise (SOE) in South Africa. Monitoring and reporting were undertaken for seven years for more than 400 wetland, river and ephemeral channel pipeline crossings located over a distance of 555 km from 2009 to 2015.
- Obtaining an M.Sc cum laude from the University of Pretoria, Department of Plant Science in 2010. Research was focused in the field of vegetation ecology and investigated the phytosociology of peat swamp forest wetlands impacted by agriculture and related land use activities.

Capabilities and Experience:

Position:	**Wetland Ecologist**	**Duration:**	**11 years**

Date of employment: March 2007 to present

Employer:

Imperata Consulting, South Africa

Type of Projects:

Wetland/Watercourse Specialist Consulting

Scope of Employer's Contract:

Watercourse specialist consulting for Scoping and feasibility studies, Environmental Impact Assessments (EIAs), Environmental Management Plans (EMPs), Water Use License Applications (WULAs), watercourse rehabilitation and monitoring for different project phases.

Specific Duties and Responsibilities/ Scope of Work:

- Identification, classification and delineation (mapping) of various watercourse types
- Watercourse identification for early environmental planning/screening purposes, risk assessments and due diligence studies
- Assessments of the ecological condition of different watercourse types
- Assessment of ecosystem services performed by wetlands
- Watercourse rehabilitation, including planning, identification and the selection of targeted watercourse areas for rehabilitation, as well recommendations regarding rehabilitation interventions and actions.
- Biomonitoring of different types of watercourses during different stages of a project lifecycle, including monitoring after the implementation of watercourse rehabilitation interventions/actions
- Project specific impact assessment of watercourses and the recommendation of applicable mitigation measures.
- Green Star accreditation Eco-Conditional specialist assessments for office buildings based on criteria from the Green Building Council of South Africa (GBCSA).
- Risk matrix assessments of wetlands and other watercourses to determine the applicability of a General Authorisation (GA), or a Water Use License (WUL), for Section 21 (*c*) and (*i*) water use activities based on Government Notice (GN) 509 published in August 2016.
- Management of multi-member specialist teams for inter-disciplinary wetland and river studies.

Position:	**Wetland Ecologist**	**Duration:**	**1 years**

Date of employment: January 2006 to February 2007

Employer:

Strategic Environmental Focus

Type of Project:

Wetland Specialist Consulting

Scope of Employer's Contract:

Wetland specialist consulting for Scoping studies, Environmental Impact Assessments (EIAs) and Environmental Management Plans (EMPs).

Specific Duties and Responsibilities/ Scope of Work:

- Delineation of wetlands and riparian habitat
- Wetland ecosystem functional assessments.
- Strategic wetland assessments and mapping, including wetland inventories.
- Description and analyses of vegetation, including the identification and mapping of sensitive vegetation units.

Publications:

- Grobler, R., Bredenkamp, G. & Grundling, P-L. 2004. Subsistence farming and conservation constrains in coastal peat swamp forests of the Kosi Bay Lake System, Maputaland, South Africa. Géocarrefour 79: 4.
- Grundling, P. & Grobler, R. 2005. Peatlands and mires of South Africa. In: Steiner, G.M. (ed.) Mires from Siberia to Tierra Del Fuego. Stapfia 85, Landesmuseen Neue Serie 35, pp. 379-396.
- Sliva J., Grundling P-L., Kotze D., Ellery F., Moning C., Grobler R., Taylor P.B. 2005. MAPUTALAND – Wise Use Management in Coastal Peatland Swamp Forests in Maputaland, Mozambique / South Africa. Wetlands International, Project No: WGP2 – 36 GPI 56.

Referrals:

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Name: Dr Piet-Louis Grundling

Position: Deputy Director: Programme Implementation, Working for Wetlands, NRM: Wetland Programmes

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