ALTERNATIVE CLOSURE AND REHABILITATION PROJECT AT THE TSHIPI BORWA MINE:

DESIGN AND BIODIVERSITY IMPACT ASSESSMENT

PREPARED FOR

SLR CONSULTING (AFRICA) (PTY) LTD

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DOCUMENT GUIDE

The Document Guide below is for reference to the procedural requirements for environmental authorisation applications in accordance to GN267 of 24 March 2017, as it pertains to NEMA.

No.	Requirement	Section in report
a)	Details of -	
(i)	The specialist who prepared the report	
(ii)	The expertise of that specialist to compile a specialist report including a curriculum vitae	
b)	A declaration that the specialist is independent	
c)	An indication of the scope of, and the purpose for which, the report was prepared	Section 1.1
cA)	An indication of the quality and age of base data used for the specialist report	Section 1.1 and 1.2
cB)	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 3
d)	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3
e)	A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 1.1.1 and 1.1.2
f)	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives	Section 5
g)	An identification of any areas to be avoided, including buffers	N/A
h)	A map superimposing the activity including the associated structure and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers	N/A
i)	A description of any assumption made and any uncertainties or gaps in knowledge	Sections 1.2
j)	A description the findings and potential implication\s of such findings on the impact of the proposed activity, including identified alternatives on the environment or activities	Section 3, 4 and 5
k)	Any mitigation measures for inclusion in the EMPr	Section 10
l)	Any conditions for inclusion in the environmental authorisation	Section 10
m)	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8 and 9
n)	A reasoned opinion -	
(i)	As to whether the proposed activity, activities or portions thereof should be authorised	Section 10.5
(iA)	Regarding the acceptability of the proposed activity or activities	Section 10.5
(ii)	If the opinion is that the proposed activity, activities 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	Section 10.5
o)	A description of any consultation process that was undertaken during the course of preparing the specialist report	N/A
p)	A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
q)	Any other information requested by the competent authority	N/A

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1. INTRODUCTION

Scientific Aquatic Services (SAS) was commissioned to determine the value and applicability of using a pit-lake as a comparative biodiversity support area, from a biodiversity resource management point of view, for the Tshipi e'Ntle Tshipi Borwa Manganese Mine.

Tshipi é Ntle Manganese Mining (Pty) Ltd (Tshipi) currently operates the Tshipi Borwa open pit manganese mine located on the farms Mamatwan 331 and Moab 700, approximately 18 km south of Hotazel and 40 km north of Kathu in the Joe Morolong Local Municipality and the John Taolo Gaetsewe District Municipality in the Northern Cape Province. Tshipi currently holds the following authorisations:

- A mining right (NC/30/5/1/2/2/0206MR) issued by the Department of Mineral Resources (DMR);
- An Environmental Management Programme report (EMPr) approved by the DMR;
- An environmental authorisation (NC/30/5/1/2/2/206/000083 EM) issued by the DMR; and
- A Water Use Licence (IWUL) (10/D41K/AGJ/1735) issued by the Department of Water and Sanitation.

Key mine infrastructure includes an open pit, haul roads, run-of mine ore tip, a primary crusher, a secondary crushing and screening plant, various stockpiles for crushed and product ore, a train load-out facility, a private siding, offices, workshops, warehouses and ancillary buildings, an access control facility, various access roads, diesel generator house, electrical reticulation, clean and dirty water storage dams, water reticulation pipelines and drains, topsoil stockpiles and waste rock dumps. The mine has an anticipated life of mine of approximately 25 years and has been operational since 2012.

The approved EMPr commits Tshipi to restore the surface to pre-mining state of wilderness and grazing and requires that the open pit is backfilled. Recent operation optimisation investigations indicate that when considering environmental, socio-economic, technical, commercial and legal factors, and, completely backfilling the open pit is sub-optimal. An alternative closure and rehabilitation strategy offers:

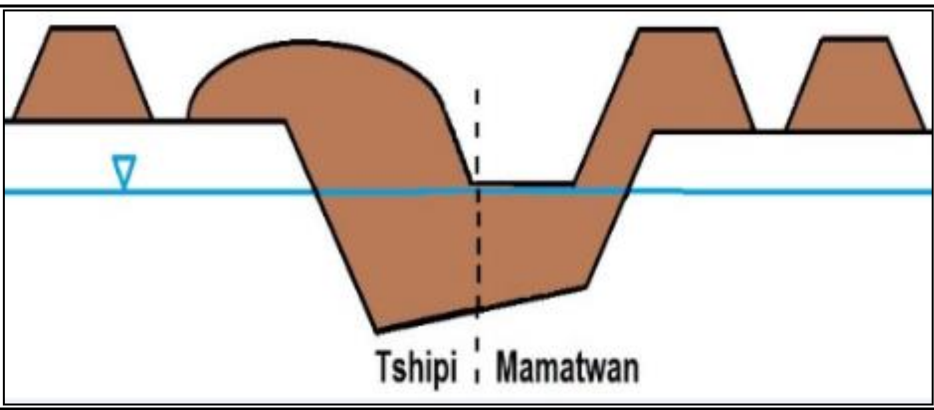
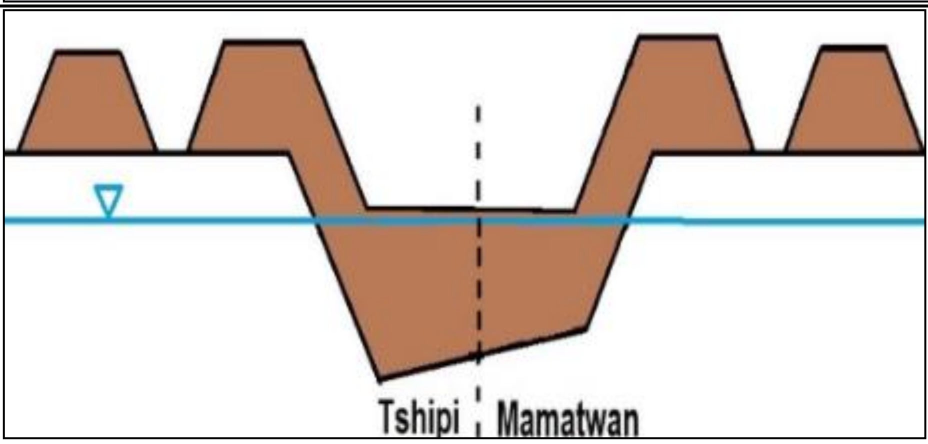
- The opportunities for enhanced biodiversity habitats with a different backfill approach particularly in terms of topographic variety and access to surface water;
- The opportunities for enhanced land use increase with access to surface water;

- ➢ An alternative closure option will allow for earlier rehabilitation of waste rock dumps; and
- ➢ Completely backfilling the open pit is likely to sterilise an underground resource located to the north of the current approved open pit. The associated loss of employment, procurement, taxes and foreign exchange earnings is significant and will be a material net loss to the region and the country;

Tshipi is therefore proposing to change the current closure commitment to achieve a more sustainable and optimised outcome. In this regard, the proposed project focusses on:

- ➢ Concurrent backfill only i.e. in-pit dumping during mining operations only;
- ➢ Sloping and rehabilitation of waste rock dumps remaining on surface;
- ➢ Access to readily available future water supply; and
- ➢ Optimisation of the surface landforms and partially backfilled pit from a biodiversity, rehabilitation, land use and pollution prevention perspective.

Work undertaken to date has determined that four high level options are available for the closure of the pit which are defined in figure 1 below.

Complete Backfill	
Partial backfill	

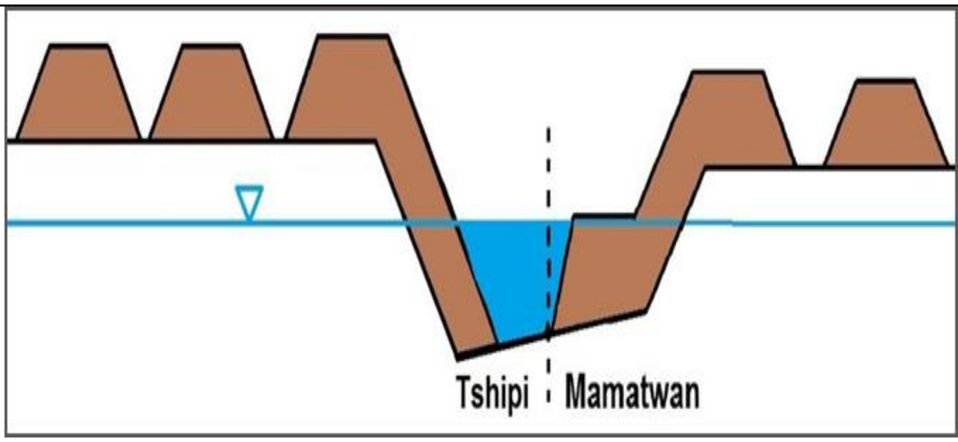
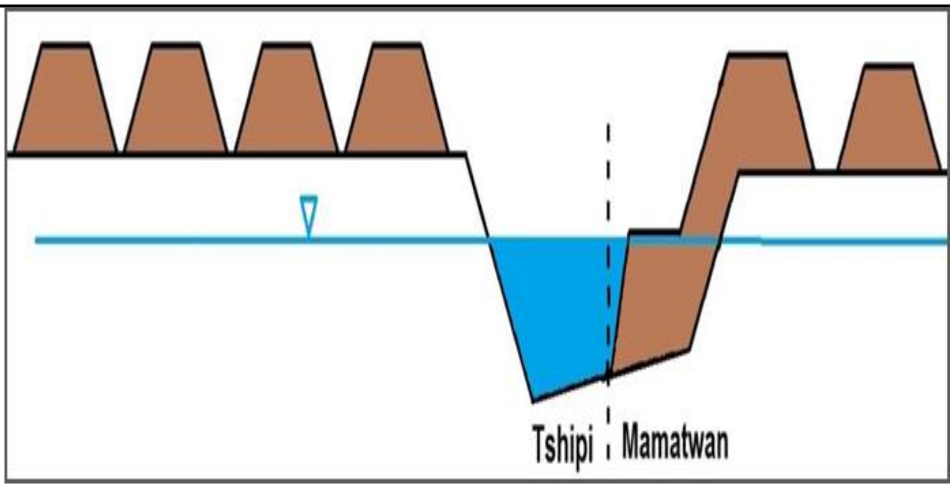
Concurrent backfilling i.e In-pit dumping only	
No In-pit Dumping and no Backfill	

Figure 1: Four high level pit closure options developed prior to the initiation of this study.

1.1 Scope of Study

The aim of this study is to:

1) define the suitability of the development of different closure options as a comparative assessment in terms of the biodiversity support and ecological value that may be created by the various post closure land use options; and
2) Conduct and impact assessment (unmitigated vs mitigated) and to create a management plan for the chosen alternative to maximise the positive and minimize the negative aspects associated with the closure of the pit.

1.1.1 Freshwater Assessment Scope

The points below summarise the aquatic assessments undertaken to meet the objective of the scope of study:

1. By assessing the pit characteristics, including aspects such as depth, slope, substrate and water quality it can be determined whether there is potential to design the pit to have an End of Life Pit Lake (EPL) present which can be viewed as a biological asset. This is further expanded upon in the points below.
2. An assessment of the aquatic ecology of two analogous lacustrine systems, was undertaken namely the Kuruman Eye and a dam to the south of Kathu, which is augmented by discharge from the Sishen Mine.
    a. The field assessments took place with focus on:
        i. Assessment of biota specific water quality from the analogue sites as well as the modeled water quality of the proposed pit-lake;
        ii. Visual assessment of the analogue sites focusing on habitat characteristics and habitat and cover availability for both aquatic macro-invertebrates and fish;
        iii. An assessment of Lacustrine macro-invertebrate community diversity and sensitivity in the two analogue sites;
        iv. An assessment of fish community diversity and sensitivity as well as habitat availability for fish in the two analogue sites.
3. Toxicological assessment of water samples from each analogous site although some data is not yet available. The following acute screening tests were used:
    a. *Vibrio fischeri bacterial* bioluminescence test representative of the bacterial trophic level.
    b. The Algal Growth Potential (*Selenastrum capricornutum*) test representative of the producer trophic level in the system
    c. *Daphnia pulex* test representative of aquatic macro-invertebrates.
    d. *Poecilia reticulata* test representative of the secondary consumer trophic level.
4. Water quality analyses including pH, electrical conductivity, temperature, clarity and temperature as well as further chemical analyses by a SANAS registered laboratory. Results are compared to The South African water quality guidelines volume 7, Aquatic ecosystems (DWAF, 1996) as well as comparing the data from the Tshipi pit (T1) to the two analogue sites namely the Kuruman eye (T2) and the Kathu Dam (T3);
5. A detailed freshwater ecological report will be compiled including the opportunities and constraints to supporting aquatic biota in each analogous site and specifically the Tshipi Pit;
6. Based on the findings and assessment of the suitability of the use of the EPL, from an aquatic ecological point of view, as a comparative biodiversity support area will be discussed.

7. Some design criteria to enhance the value of an EPL, should the EPL be identified as the most desirable post closure land use, will be provided to improve the habitat and cover availability for aquatic macro-invertebrates and fish.

1.1.2 Terrestrial Ecological Assessment Scope

The points below summarise the aquatic assessments undertaken to meet the objective of the scope of study:

1. A high-level assessment of the terrestrial ecology of two analogous freshwater systems was undertaken, namely the Kuruman Eye and a dam to the south of Kathu which is recharged through a combination of rainfall and water discharge from the Sishen Mine.
    a. The field assessments took place with focus on:
        i. Assessment of the general faunal and floral habitat characteristics at each of the above sites in order to develop a comparative baseline to which the EPL model can be compared; and
        ii. An assessment of the faunal and floral species diversity at each of the analogous sites;
2. A high level terrestrial ecological report will be compiled including habitat analysis and suitability of each analogous site. Based on the findings an assessment of the suitability of the various closure options will be undertaken, from a terrestrial ecological point of view, as a comparative biodiversity support area will be discussed.

1.2 Limitations of Study

1.2.1 Freshwater Study Assumptions and Limitations

The following points serve to indicate the assumptions and limitations of the freshwater study.

- ***Availability of analogous reference site:*** This study should be considered as a rapid assessment and only two analogous sites were assessed. It is important to note that the assessments were made on impoundments and not EPLs and as such some inaccuracies in comparisons to expected conditions is deemed likely. This is especially true of the water quality aspects and thus a different driver of ecological response, which most likely has a different hydrogeological origin, and thus will have different characteristics to that expected at the Tshipi Borwa Mine;
- ***Temporal variability:*** Aquatic and terrestrial ecosystems are dynamic and complex. It is likely that aspects, some of which may be important, could have been overlooked. The data presented in this report are based on a single site visit, undertaken in summer (January 2019). The effects of natural seasonal and long-term variation in the

ecological conditions and aquatic biota found in the streams are, therefore, unknown. The data gathered is however deemed acceptable for strategic decision making; and

- ***Artificial nature of the systems:*** The two analogue sites assessed are artificially derived systems and over an extended period of time fish have been introduced into the systems by anglers, as well as through potential domestic escapee introductions. Thus, the fish community composition of the analogue sites must be considered with caution as it is not entirely representative of the local and regional ichthyofaunal assemblage.

1.2.2 Terrestrial Ecological Study Assumptions and Limitations

The following points serve to indicate the assumptions and limitations of the biodiversity study:

- ***Availability of analogous reference site:*** Two analogous sites were assessed each presenting varied ecological characteristics. It must be noted that each site assessment was conducted at a high level and not in detail. The assessment was undertaken to allow the terrestrial habitat functioning in terms of the greater landscape to be determined and understood, so as to better inform and determine the perceived viability of the proposed Tshipi pit lake;
- ***Temporal variability:*** Terrestrial ecosystems are dynamic and complex by nature. It is likely that aspects, some of which may be important, could have been overlooked. The data presented in this report are based on a single site visit, undertaken in summer (January 2019). The effects of natural seasonal and long-term variation in the ecological conditions are, therefore, unknown, however the data gathered is deemed acceptable for strategic decision making; and
- Not all the species at each site were assessed, instead a rapid assessment combined with previous studies from the area and background data was used to derive an understanding of the functioning and importance of each analogue site, however the data gathered is deemed acceptable for strategic decision making.

2. REGIONAL AQUATIC ECOLOGY

The following section contains data accessed as part of the desktop assessment and presented as a "dashboard style" report below (Table 1). The dashboard report aims to present concise summaries of the data on as few pages as possible in order to allow for integration of results by the reader to take place. Where required, further discussion and interpretation is provided.

It is important to note that although all data sources used provide useful and often verifiable, high quality data, the various databases used do not always provide an entirely accurate indication of the actual site-specific characteristics as assessed within the study area. However, this information is considered useful as background information to the study. Thus, this data was used as a guideline to inform and guide the study to ensure the most appropriate outcome from a freshwater resource management perspective.

Table 1: Desktop data relating to the character of freshwater resources associated with the study areas and surrounding region.

Aquatic ecoregion and sub-regions in which the study areas is located		
Aquatic resource	Sishen Dam, Tshipi	Kuruman Eye
Ecoregion	Southern Kalahari	Ghaap plateu
Catchment	Orange	Orange
Quaternary Catchment	D41J	D41L
WMA	Lower Vaal	Lower Vaal
subWMA	Molopo	Molopo
Dominant characteristics of the Level (29.01 and 30.01) (Kleynhans et al., 2007)		
Level II Ecoregion	**29.01**	**30.01**
Dominant primary terrain morphology	Plains; Low relief	Plains; Low relief
Dominant primary vegetation types	Shrubby Kalahari Dune bushveld, Kalahari plains thorn bushveld	Kalahari plateau bushveld
Altitude (m a.m.s.l)	500-1700	900-1700
MAP (mm)	0-500	200 to 500
Coefficient of Variation (% of MAP)	30 to >40	30 to 40
Rainfall concentration index	55 to >65	55-65
Rainfall seasonality	Mid to very late summer	Mid to late summer
Mean annual temp. (°C)	14-22	16-20
Summer temperature (February)	14>32	14-32
Winter temperature (July)	-2-22	0-20
Median annual simulated runoff (mm)	<5 to 60	<5 to 40

Ecological Status of the most proximal sub-quaternary reach (DWS, 2014)			
Sub-quaternary reach	D41K	D41L	D41G
Proximity to focus area	19km north east	10.7 km west	55km north east
Assessed by expert?	No	Yes	Yes
PES Category Median	-	E	C
Mean Ecological Importance (EI) Class	Moderate	Low	Moderate
Mean Ecological Sensitivity (ES) Class	-	Moderate	Low
Default Ecological Class (based on median PES and highest EI or ES mean)	C (Moderate)	C (Moderate)	C (Moderate)

CBA = Critical Biodiversity Area; DWS = Department of Water and Sanitation; EI = Ecological Importance; ES = Ecological Sensitivity; ESA = Ecological Support Area; m.a.m.s.l = Metres above Mean Sea Level; MAP = Mean Annual Precipitation; NFEPA = National Freshwater Ecosystem Priority Areas; PES = Present Ecological State WMA = Water Management Area

2.1 Ecological Status of Sub-Quaternary Catchments [Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database]

The Present Ecological State (PES) / Ecological Importance (EI) database, as developed by the DWS Resource Quality Information Services (RQIS) department, was utilised to obtain additional background information on the project area. The information from this database is based on information at a sub-quaternary catchment reach (SQR) level. Descriptions of the aquatic ecology is based on information collated by the DWS RQIS department from available sources of reliable information, such as the South African River Health Programme (SA RHP) sites, Ecological Water Requirements (EWR) sites and Hydro Water Management system (WMS) sites. In this regard, information for the SQRs of rivers in the vicinity of the study areas were obtained. The rivers and their applicable SQR points are as follows:

- D41L-02303; and
- D41G-02056 (Moshaweng).

Key information on fish species, invertebrates and background conditions, associated with the above listed assessment areas, as contained in this database and pertaining to the (PES), (EI) and Ecological Sensitivity (ES) for the most applicable riverine sub-quaternary reaches, are presented below.

D41L-02303

The EI data for SQR D41L-02303 indicates that the following fish species have previously been reported from this sub-quaternary reach:

- *Enteromius brevipinnis;*
- *Enteromius paludinosus;*
- *Clarias gariepinus;*
- *Pseudocrenilabrus philander; and*
- *Tilapia sparrmani*.

Enteromius brevipinnis is highly unlikely to occur in the area since it is known to occur in lowveld streams of the Limpopo and Phongola River Systems. All the remaining species can be considered common and widespread and are generally considered tolerant species.

D41G-02056 (Moshaweng)

The EI data for SQR D41G-02056 (Moshaweng) indicate that the following macro-invertebrate taxa have previously been reported from this sub-quaternary reach:

Ancylidae	*Hydropsychidae 1sp.*	*Tabanidae*
Aeshnidae	*Hydropsychidae 2sp.*	*Veliidae/Mesoveliidae*
Baetidae 1 sp.	*Hirudinea*	
Belostomatidae	*Hydrophilidae*	
Caenidae	*Naucoridae*	
Ceratopogonidae	*Muscidae*	
Chironomidae	*Oligochaeta*	
Coenagrionidae	*Physidae*	
Corixidae	*Planorbinae*	
Culicidae	*Pleidae*	
Gerridae	*Potamonautidae*	
Gomphidae	*Simuliidae*	
Hydracarina	*Sphaeriidae*	

3. DESCRIPTION OF THE FRESHWATER ECOLOGY OF THE ANALOGUE SITES

The water quality and toxicological properties as well as the biota present within the water at the bottom of the Tshipi Borwa Pit was compared to that of two analogue sites, namely:

1. The Kuruman eye – a natural spring that has been impounded in the centre of the town of Kuruman; and
2. The Kathu Dam, an impoundment south of Kathu which receives excess water pumped from the Sishen mine from time to time.

The locations of these sites are presented in Figures 2 and 3 below.

The dashboard report below aims to present the key data applicable to the three sites which are required to consider the aquatic ecological value of waterbodies in the area. The discussion sections aim to guide the decision-making process by briefly introducing opportunities and constraints based on the findings made at each site.

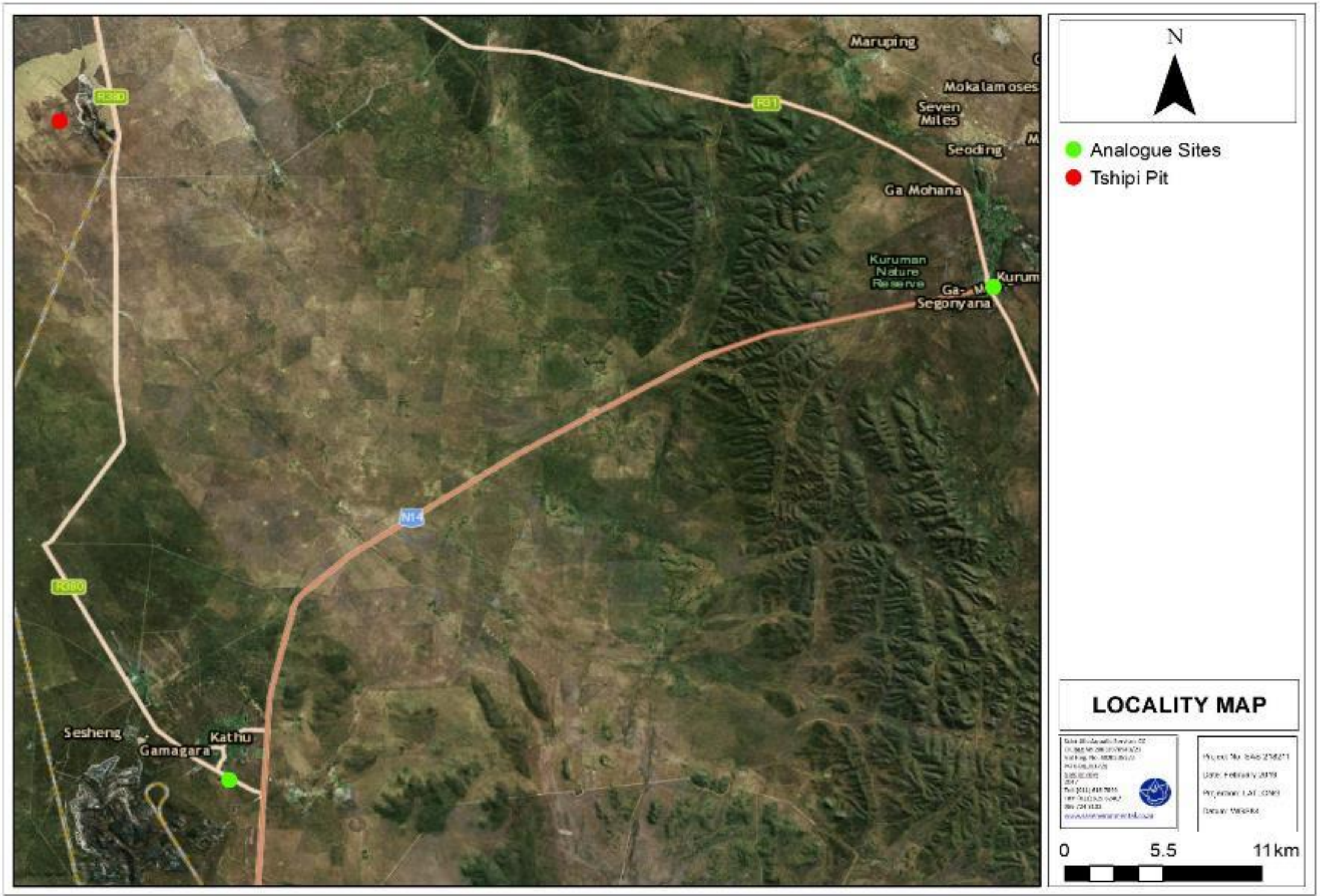


Figure 2: Location of the Tshipi Pit in relation to the two assessed analogue sites presented on a digital satellite image of the area.

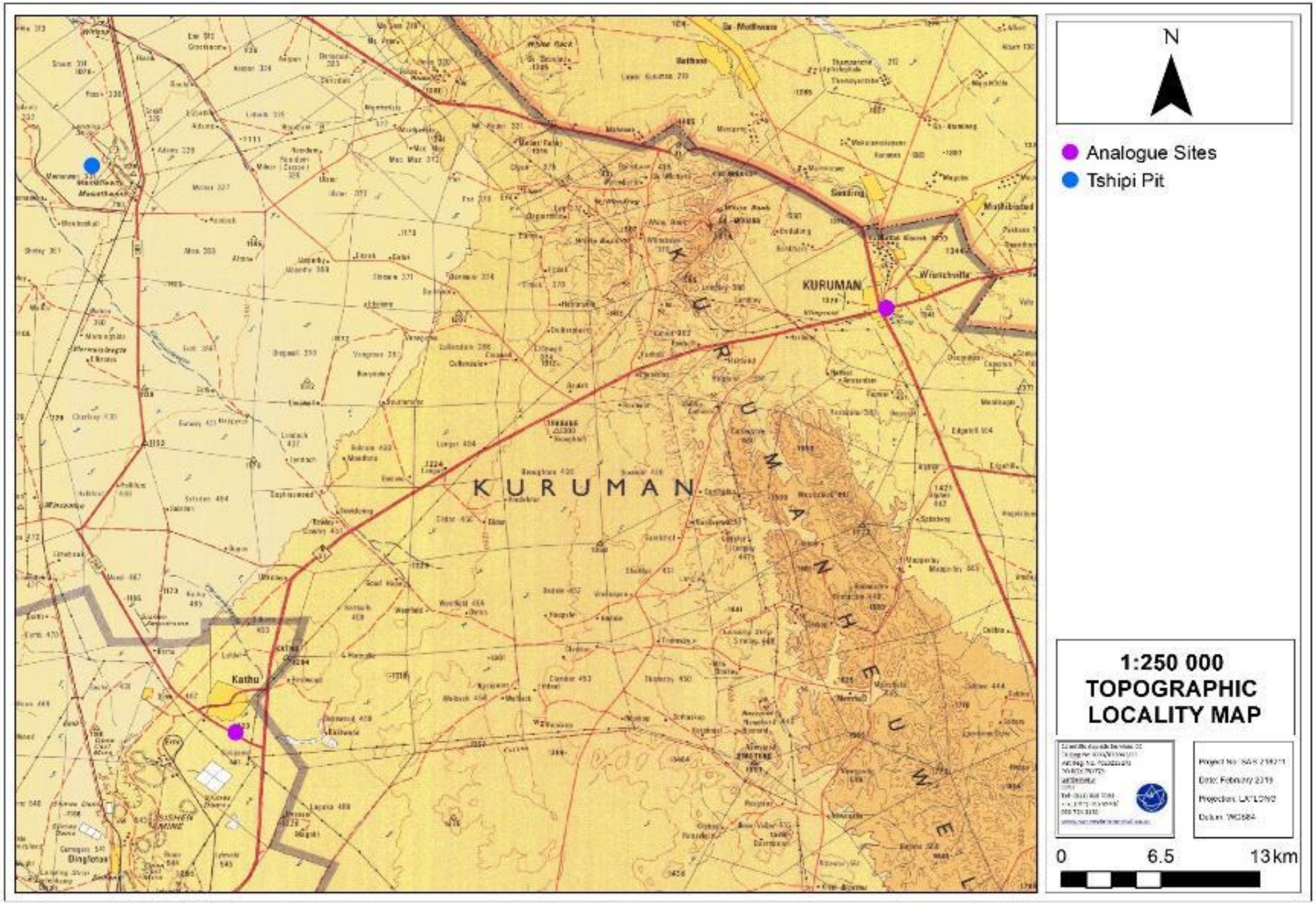


Figure 3: Location of the Tshipi Pit in relation to the two assessed analogue sites presented on a 1:250 000 topographic map.

3.1 The Kuruman eye

3.1.1. Background Information

The Kuruman eye has been defined as an "inexhaustible" spring delivering 20 million litres of clear water a day to the surface. The eye was discovered in 1801 by Samuel Daniel. It was declared as a National monument in September 1992. The eye is formed through geohydrological processes in a karst environment. The dashboard report which follows aims to describe the general ecology of the feature.

Kuruman Eye

In situ physico-chemical water quality

		Historical data
pH	7.2	Comparing data from this study to available historical data, water quality is stable with low concentrations of metals and metal salts as well as low concentrations of sulphate while nitrate concentrations indicate mesotrophic conditions.
EC (mS/m)	37	
DO (mg/ℓ)	6.24	
DO (% sat)	95.2	
Temp (°C)	28.7	
Clarity	>1m	

Comment:

- The EC value is relatively low indicating that the dissolved salt concentrations are ideal for supporting a diverse and sensitive lacustrine community;
- The pH value indicates largely neutral conditions, supporting a diverse and sensitive lacustrine community;
- The saturation of DO can be considered as ideal for supporting a diverse and sensitive aquatic community;
- The temperature of the water was high due to the shallow nature of the system and the high temperatures experienced by the region. Only species that can tolerate the elevated temperatures will survive in shallow impoundments in the area;
- The water is extremely clear and ideal for supporting a diverse aquatic community; and
- Overall, water in this system can be considered highly suitable for supporting a diverse and sensitive lacustrine community.

Aquatic macro-invertebrate community characteristics

Corixidae
Coenagrionidae
Baetidae
Potamonautidae

Comment:
Detailed sampling of the eye was not permitted, however, based on visual observations several macro-invertebrate taxa were identified. The diversity of substrate present and the presence of both rooted emergent vegetation and bankside vegetation as well as floating aquatic vegetation, provides ideal habitat and cover for a diverse aquatic macro-invertebrate community.

The taxa identified are tolerant and widespread and provide an indication of what could be expected to occur, as a minimum, in a lacustrine system in the area, provided that water quality is of an acceptable range.

Habitat

Habitat	
Depth diversity	The impoundment is shallow with little variation in depth profiles. The entire impoundment is euphotic with no areas deep enough to prevent growth of rooted emergent vegetation.
Cover diversity	Most important cover is provided by the rooted emergent vegetation and bankside vegetation as well as floating aquatic vegetation
Substrate conditions	Gravel substrate and some steep rocky areas along the edges of the impoundment.

Fish Community Assessment

Species Present: Detailed sampling of the eye was not permitted, however, based on visual observations several fish species were identified:

Cyprinus carpio (exotic)	*Clarias gariepinus* (indigenous but undesirable)
Oreochrmis mossambicus	*Tilapia sparrmanii*
Pseudocrenilbarus philander	Unidentified barbs and goldfish

Tolerance and Sensitivity: The community supported can be considered tolerant but diverse. It is clear that introduction of fish species has taken place over time.

Potential important species supported: The system has the potential to support most species which are tolerant of lacustrine conditions

Discussion and implications for potential End Pit Lake (EPL)

The data from this site indicates that a stable and diverse lacustrine community can potentially be supported in EPLs of the region. Reasonable water quality as well as the presence of productive shallow areas which can support rooted emergent vegetation is, however, deemed essential to create a sustainable ecosystem. The presence of gravel beds will allow some species such as *Oreochrmis. mossambicus* to successfully spawn and this criterion is considered important in the design of an EPL. It is deemed possible that less desirable species such as, *Clarias gariepinus* and *Cyprinus carpio* will become established in the EPL and will impact on the aquatic ecosystem. These fish species also have the potential to increase turbidity which will make the EPL less visually attractive.

3.2 The Kathu Dam

3.2.1. Background Information

The Kathu Dam is located to the west of the town of Kathu. The dam receives excess water from the Sishen Mine. At the time of assessment water levels were very low with water limited to the deeper old quarries within the dam.

Around the inundated portions of the dam the landscape habitats include rocky steep areas, some small areas where gravel deposits are present and deeper open water where floating aquatic vegetation occurred. This dam forms an excellent site for comparative purposes and provides a good opportunity to determine what can be expected of an EPL in the area. The dashboard report which follows aims to describe the general ecology of the feature.

Kathu Dam

In situ physico-chemical water quality

		Laboratory analyses key parameters of concern
pH	8.84	Al, Pb, Se and Zn exceed the DWS TWQR
EC (mS/m)	56.5	
DO (mg/ℓ)	7.97	
DO (% sat)	89.6	
Temp (°C)	21	
Res chlorine	Present	
Clarity	>47cm	

- Dissolved salt concentrations are considered adequate for supporting a diverse and sensitive aquatic community;
- The metals aluminium, lead, selenium and zinc exceed the DWS TWQR which may lead to an impact on the aquatic community of the system. Only taxa that can tolerate the higher salt concentrations, and specifically the concentrations of metal salts, will survive in the system;
- Water clarity was limited, which will affect the extent of the euphotic zone of the waterbody ; and
- The system can be considered mesotrophic and thus some nuisance algal growth will occur. This is supported by the findings of the application of the Algal Growth Potential Test.

Aquatic macro-invertebrate community Characteristics

Corixidae
Coenagrionidae
Baetidae
Potamonautidae
Gomphidae
Lestidae

Comment:
A relatively diverse aquatic macro-invertebrate community was observed. The taxa present are tolerant of lacustrine conditions and are relatedly tolerant to impaired water quality. The community sampled was most diverse and abundant in the aquatic vegetation in the system, while the small gravel patches provided habitat for taxa such as the Gomphidae family of the order Odonata. The steep bedrock walls of the old quarry sections were of limited value in terms of aquatic macro-invertebrate habitat. This indicates that the presence of aquatic vegetation, and to a lesser degree gravel deposits, are essential to support a stable and diverse aquatic macro-invertebrate community of reasonable diversity.

The taxa identified are tolerant and widespread and provide an indication of what could be expected to occur, as a minimum, in a lacustrine system in the area, provided that water quality is of an acceptable range.

Habitat

Depth diversity	The impoundment has a diversity of depth with both euphotic zones as well as deeper areas where rooted plants cannot grow.
Cover diversity	Most important cover is provided by suspended aquatic vegetation. When the impoundment is fuller bankside vegetation may be available as a habitat and cover source.
Substrate conditions	Steep rocky areas along the edges of the impoundment with isolated gravel deposits present.

Fish Community Assessment

Species Present: Based on visual observations and basic sampling undertaken several fish species were identified:
Cyprinus Carpio (exotic) *Clarias Gariepinus* (indigenous but undesirable)
Labeobarbus aeneus *Micropterus salmoides* (exotic)
Labeobarbus kimberleyensis and *Oreochrmis mossambicus* reported by local anglers

Tolerance and Sensitivity: The community supported can be considered tolerant but diverse. It is clear that introduction of fish species has taken place over time. Species such as *Labeobarbus aeneus* and *Labeobarbus kimberleyensis* are unlikely to be able to successfully spawn in this system, and to ensure spawning in an EPL specific design will be required.

Potential important species supported: The system has the potential to support most species which are tolerant of lacustrine conditions.

Toxicological Properties

Test	% mortality/ growth
V. fischeri	-26
S. capricornutum	+180
D. pulex	0
P. reticulata	Not available
Slight acute hazard	Class 2

- Bacterial growth inhibition is significant (exceeds 10%);
- Algal growth stimulation is also significant and indicates a very signficant eutrophication risk; and
- Water from this site presents a Slight Acute Hazard (Class 2) toxicological risk on at least one trophic level (bacteria).

Discussion and implications for potential End Pit Lake (EPL)

The data from this site indicates that a stable and diverse lacustrine community can potentially be supported in EPLs of the region. Reasonable water quality as well as the presence of productive shallow areas which can support rooted emergent vegetation is, however, deemed essential to create a sustainable ecosystem. The presence of gravel beds will allow some species such as *Oreochrmis mossambicus and Labeobarbus aeneus* to successfully spawn and this criterion is considered important in the design of an EPL. It is deemed possible that less desirable species such as, *Clarias gariepinus* and *Cyprinus carpio* will become established in the EPL and will impact on the aquatic ecosystem. These fish species also have the potential to increase turbidity which will make the EPL less visually attractive. Furthermore, *Micropterus salmoides* may become established which could impact on other fish species, the aquatic macro-invertebrate community and the general stability of the lake as a whole.

3.3 The Tshipi Borwa Pit

3.3.1. Background Information

The Tshipi Borwa pit is currently operational. Some water collects in the bottom of the pit from time to time. By assessing the pit characteristics, including aspects such as depth, slope, substrate and water quality it can be determined whether there is potential to design the pit to have an EPL present which can be viewed as a biological asset from a terrestrial ecological point of view. The data presented in the table below is based on the current conditions in the pit, with specific mention of physical attributes as well as water quality attributes. The macro-invertebrate taxa present in the water at the bottom of the pit lake were also defined. The table highlights what opportunities and constraints are foreseen given the observations made of the pit at the time of assessment.

Existing pit (site T1)

***In situ* physico-chemical water quality**

		Laboratory analyses key concerns
pH	8.05	TDS, Nitrate, Al, B, Mn, Na and Rb Of lesser concern are Ca, Cd Co Li, Se Sr and Zn
EC (mS/m)	182	
DO (mg/ℓ)	7.52	
DO (% sat)	84.5	
Temp (℃)	21.0	
Res chlorine	Trace	
Clarity	96cm	

Comment on biota specific water quality:

- pH exceeds 8.5 and is 22.8% higher compared to that measured at site T2 (Kuruman Eye). The percentage difference exceeds 5% and do not comply with the DWAF (1996) recommendation;
- EC is very high and indicates a high dissolved salt concentration. Some osmotic stress on biota is deemed likely;
- DO saturation complies with the 80% guideline recommendation and DO concentration is 27.7% higher compared to site T2 and 5.6% lower than the Kathu Dam. No negative impact on aquatic community integrity is anticipated;
- The high nitrate concentrations indicate eutrophication risk (as also supported by algal growth stimulation in the WET test); and
- Compared to the DWAF (1996) guidelines, concentrations of Al, Pb, Se and Zn exceed the recommended guidelines.

Aquatic macro-invertebrate community Characteristics

Gerridae Libellulidae

Comment:
The aquatic macro-invertebrates present were tolerant taxa which occurred in low abundances. Water quality as well as the isolated nature of water in the bottom of the pit limit the ability of aquatic macro-invertebrates to colonise the pit at the current time. Establishment of an aquatic macro-invertebrate community would most likely take a long time, but the trophic status of the water would support the community.

Habitat (current pit shell)		Fish Community Assessment
Depth diversity	The impoundment would be deep with a very limited euphotic zone. Large expanses of the EPL would thus be mostly devoid of life unless the EPL was correctly shaped as part of closure.	**Species Present:** No fish were present in the system.
Cover diversity	It may be difficult for bankside vegetation to become established (even with appropriate rehabilitation efforts).	**Tolerance and Sensitivity** Not Applicable.
Substrate conditions	Most important cover is provided by rock in scree slopes. Soft overburden could be used to create gravel and mud beds to improve habitat diversity and spawning areas in shallower parts of the EPL.	**Potential important species supported:** The system has the potential to support most species which are tolerant of lacustrine conditions.

Test	% mortality/ growth
V. fischeri	-10.0
S. capricornutum	+207
D. pulex	0
P. reticulata	Not available
No acute hazard	Class 1

- Bacterial growth inhibition is not significant (<10%);
- Algal growth stimulation is significant and indicates a very signficant eutrophication risk;
- No macro-invertebrate mortality occurred and fish test results are not yet available; and
- Water from this site thus presents a No Acute Hazard (Class 1) toxicological risk to -invertebrates, bacteria and algae.

Discussion and implications for potential End Pit Lake (EPL)

The data from this site indicates that water quality may be a limiting factor for the establishment of an EPL. If water quality impacts could be overcome, the pit would need to be partially backfilled and shaped to provide productive shallow areas which can support rooted emergent vegetation, to create a sustainable ecosystem. It would be essential to create gravel beds which will allow some fish species such as *O. mossambicus* and *L. aeneus* to successfully spawn. It is deemed possible that less desirable species, such as *C. gariepinus* and *C. carpio* will become established in the EPL and will impact on any aquatic ecosystems that have established. These fish species also have the potential to increase turbidity which will make the EPL less visually attractive. Furthermore, *M. salmoides* may become established which could impact on other fish species, aquatic macro-invertebrate community and the general stability of the lake as a whole.

4. DESCRIPTION OF THE TERRESTRIAL ECOLOGY OF THE PIT AND ANALOGUE SITES

4.1 Results of the Desktop Analysis for Tshipi Mine

The following table contains data accessed as part of the desktop assessment pertaining to the conservation characteristics associated with Tshipi Mine. It is important to note that although all data sources used provide useful and often verifiable high-quality data, the various databases do not always provide an entirely accurate indication of the actual biodiversity characteristics at specific sites assessed within the study area. Furthermore, it must be noted that the below presented data is not applicable to the analogue sites assessed.

Table 2: Summary of the conservation characteristics for the Tshipi Mine.

Details of the study area in terms of Mucina & Rutherford (2006)	
Biome	Tshipi Mine is situated within the **Savanna Biome.**
Bioregion	Tshipi Mine is located within the **Eastern Kalahari Bushveld Bioregion**
Vegetation Type	Tshipi Mine is situated within the **Kathu Bushveld**
Conservation details pertaining to Tshipi Mine (Various databases)	
NBA (2011)	Tshipi Mine falls within an area that is currently not protected.
National Threatened Ecosystems (2011)	Tshipi Mine falls within an area that is least threatened.
NPAES (2009), SACAD (2017) and SAPAD (2017)	Tshipi Mine is not located within or near any protected or conservation areas (within a 10km radius).
IBA (2015)	Not located within or near an IBA (within 10 km).
Mining and Biodiversity Guidelines (2013)	
According to the Mining and Biodiversity guidelines, Tshipi Mine is not ranked as a priority area, nor is it located near (within 10km) an area considered to be of biodiversity importance.	
Northern Cape Critical Biodiversity Areas (2016) (Figure 3)	
The majority of Tshipi Mine falls within an area considered to be Other Natural Areas (ONA). According to the Technical Guidelines for Critical Biodiversity Areas (CBA) Maps document, ONAs consist of all those areas in good or fair ecological condition that fall outside the protected area network and have not been identified as CBAs or Ecological Support Areas (ESAs) (SANBI, 2017).	
Northern Cape Provincial Spatial Development Framework (NPSDF, 2012)	
• The proposed study area is situated within the Griqualand West Centre of Endemism) (Figure 4). Please refer to Appendix D for further detail; and • The proposed study area is situated within the Gamagara Corridor. The corridor focuses on the mining of iron and manganese (Figure 5).	

Description of the vegetation type(s) relevant to the study area (Mucina & Rutherford 2006)	
Vegetation Type	Kathu Bushveld
Climate	Summer and autumn rainfall, very dry winters
Altitude (m)	960 - 1300
MAP* (mm)	300
MAT* (°C)	18.5
MFD* (Days)	27
MAPE* (mm)	2883
MASMS* (%)	85
Distribution	Northern Cape Province
Geology & Soils	Aeolian red sand and surface calcrete, deep (>1.2m) sandu soils of Hutton and Clovelly soil forms.
Conservation	Least threatened. Target 16%. None conserved. In statutory
Vegetation & landscape features (Dominant Floral Taxa in Appendix F)	Medium-tall tree layer with *Vachellia erioloba* in places, but mostly open and including *Boscia albitrynca* as the prominent trees. Shrub layer generally most important with for example *Acacia mellifera, Diospyros lycioides* and *Lycium hirsutum*. Grass layer variable in cover.
Tall Tree	*Vachellia erioloba* (d)
Small Trees	*Senegalia mellifera* subsp. *detinens* (d), *Vachellia. leudertzii* var. *leudertzii* (k), *Boscia albitrunca* (d), *Terminalia sericea,*
Tall Shrubs	*Diospyros lycioides* subsp. *lycioides* (d), *Dichrostachys cinereal, Grewia flava, Gymnosporia buxifolia, Rhigozum brevispinosum*
Low Shrubs	*Aptosimum decumbens, Grewia retinervis, Nolletia arenosa, Sida cordifolia, Tragia dioica,*
Graminoids	*Aristida meridionals* (d), *Brachialis nigropedata* (d), *Centropedia glauca* (d), *Eragrostis lehmanniana* (d), *Schmidtia pappophoroides* (d), *Stipagrostis uniplumis, Tragus berteronianus, Anthephora* ***argentea*** (k), *Megaloprotachne albescens* (k), *Panicum kalaharense* (k)
Herbs	*Acrotome inflate, Erlangea misera, Gisekia Africana, Heliotropium cillatum, Hermbstaedtia fleckii, H. odorata, Limeum fenestratum, L. viscosum, Lotononis platycarpa, Senna italic* subsp. *arachoides, Tribulus* terrestris, *Neuradopsis bechuanensis* (k)

NBA = National Biodiversity Assessment; NPAES = National Protected Areas Expansion Strategy; SAPAD = South African Protected Areas Database; IBA = Important Bird Area; MAP – Mean annual precipitation; MAT – Mean annual temperature; MAPE – Mean annual potential evaporation; MFD = Mean Frost Days; MASMS – Mean annual soil moisture stress (% of days when evaporative demand was more than double the soil moisture supply), (d) = dominant species; (k) Kalahari endemic

4.2 Ecological Discussion of the Various Sites

An ecological study as part of the EMP Amendment for Tshipi Mine was undertaken in May 2018 by Scientific Terrestrial Services (STS180039). The data from this report as well as the assessments of the two (2) analogous sites is summarised and presented in the dashboards below.

Table 3: Discussion of the ecological characteristics of the 2 habitat units within the Tshipi Mine boundary

Kathu Thornveld Habitat	Disturbed Habitat
 	 
Terrestrial Overview	**Terrestrial Overview**
The Kathu Thornveld habitat unit is located to the west and north of the current pit and characterised by a well-developed herbaceous layer interspersed with woody species, notably that of *Grewia flava, Vachellia erioloba* and *Vachellia haematoxylon*, which are characteristic for the region. Overall, the habitat is considered in a good condition and is characterised by the presence of an abundance of the protected tree species *Vachellia erioloba* and *Vachellia haematoxylon*, listed in the National Forest Act, 1998 (Act No. 84 of 1998) (NFA), as amended in September 2011). Additionally, these areas play host to additional faunal and floral SCC such as *Harpagophytum procumbens* (Devil's Claw), *Mellivora capensis* (Honey Badger) and *Atelerix frontalis* (South African Hedgehog) which are listed as specially protected in the Northern Cape Nature Conservation Act, 2009 (Act No. 9 of 2009), *Neotis ludwigii* (Ludwig's Bustard) and *Ardeotis kori* (Kori Bustard). In addition to these species the relatively intact areas to the north and west of the pit provide habitat to many common species, including *Lepus saxatilis* (Scrub Hare); *Raphicerus campestris* (Steenbok), *Sylvicapra grimmia* (Common Duiker) and *Cynictis penicillata* (Yellow Mongoose).	This habitat unit comprises the mining infrastructure areas, and the small pockets of disturbed vegetation remaining therein or directly adjacent to the mining infrastructure (Figure 4). This habitat unit, as a result of the development and daily functioning of the mine, has been subjected to increased levels of dust, vegetation clearance, dumping of excavated material and clearing for new roads and stockpiles. As a result, the natural vegetation has decreased, creating an ideal environment for the proliferation of alien and invasive plant species. Although habitat degradation has occurred, there were still a number of *Vachellia erioloba* and *Vachellia haematoxylon* specimens, listed in the NFA, as amended in September 2011) occurring within this habitat unit. The overall faunal species diversity and abundance within this habitat unit is notably lower than that of the more intact Kathu Thornveld habitat. This is due to an increase in alien plant species, loss of habitat and increased movement of personnel and mine vehicles.

4.3 Ecological Characteristics of the Current Pit

The open cast pit is devoid of all but the hardiest alien plant species and tufts of grass (*Eragrostis* spp), with these being observed sporadically along the southern slopes (Figure 4). The lack of habitat, continuous earth moving activities, dust and noise pollution as well current backfilling activities have left the pit area largely devoid of faunal species. The exception to this is the small pools of water at the bottom of the pit, which are utilised by a small number of dragonflies such as *Trithemis kirbyi ardens* (Rock Dropwing). No other faunal species were observed along the slopes or within the pit at the time of assessment. It is further deemed unlikely that faunal species will actively utilise this area due to the constant levels of disturbance, limited vegetation growth as well as the limited accessibility to the pit area.

Figure 4: Images depicting the open cast pit at Tshipi Mine.

4.4 Ecological Characteristics of the Analogous sites

Discussed in the dashboard below are the pertinent terrestrial ecological characteristics observed at each of the analogous sites, namely the Kuruman Eyes and the small dam to the south of Kathu. The Kuruman eye is a natural waterbody that is recharged from a spring, whilst the dam by Sishen is recharged through rainfall as well as the periodic water discharge from Sishen Mine.

Table 4: Discussion of the ecological characteristics of the two analogous sites assessed.

Kuruman Eye	Sishen Dam
 	 
Terrestrial Overview	**Terrestrial Overview**
The Kuruman Eye analogous site is located within the town of Kuruman. The habitat surrounding the Kuruman Eye has been extensively transformed in order to form a park-like setting. The location and habitat modification make this site all but inaccessible to faunal species, with the exception of some insects and avifauna. Bankside vegetation consists of several alien tree species, namely *Salix babylonica* (Weeping Willow), *Melia azedarach* (Syringa) and *Pinus* spp amongst others. The herbaceous layer was dominated by *Pennisetum clandestinum* (Kikuyu) and *Eragrostis* spp. The Kuruman Eye provides a potentially good reference point in terms of the possible social aspects that could be applicable to the proposed EPL, however, in terms of ecological functionality it is a clear indicator as to the direction that should not be followed in terms of ecological objectives for the proposed EPL. However, taking into consideration the ecological importance and functioning of the Kuruman Eye prior to the development of Kuruman itself, then one could consider the Kuruman a prime example of what may be achievable with the development of the pEPL at Tshipi. The Kuruman Eye would have been a biodiversity hotspot, supporting a diversity of faunal and floral species otherwise not seen in the surrounding arid environments. This could provide a glimpse into what may be achievable with the EPL in the long term, provided it is suitably managed and modelled in order to be ecologically beneficial.	Much of the surface water at the small dam was dried up at the time of assessment, with the exception of some deeper pools within old quarries/pits. In this regard this dam provides a perfect example of the situation that is likely to occur failing proper design, planning and management of the proposed Tshipi EPL. The bank vegetation surrounding the small dam consisted of dense stands of *Arundo donax* (Spanish reed) interspersed with *Prosopis glandulosa*, both of which are alien and invasive plant species. Historical imagery indicates that several years ago the dam was full, and at this point provided habitat to several faunal species as well as being an important source of surface water. However, this analogue site also indicates that without a proper alien vegetation control plan it is likely that such species will dominate the landscape, impacting and degrading faunal and floral habitat. The dried-out state of the Sishen Dam further illustrates the fact that water recharge from rainfall alone is insufficient to maintain optimal water levels in order to maintain the desired level of habitat in order to promote faunal and floral species diversity. At the time of assessment faunal common faunal species such as *Vanellus armatus* (Blacksmith Lapwing), *Anhinga rufa* (African Darter), *Alopochen aegyptiacus* (Egyptian Goose) and *Trithemis stictica* (Violet Dropwing). The habitat present at the dam currently is deemed suitable for common faunal species, however, it is likely that historically, when the water levels were higher, habitat suitability and species diversity would have been higher.

5. END PIT LAKE ECOLOGICAL OPTIONS ANALYSIS

As discussed, and illustrated in Section 1 Figure 1, there are at present four options proposed by the mine in terms of the future closure alternatives for the current open cast pit. The options proposed are:

- Complete backfilling of the pit;
- Partial Backfill of the pit;
- In-pit dumping concurrent with mining only; and
- No in-pit dumping.

Currently Tshipi's approved commitment is to rehabilitate the surface to that of mix use of the veld as wilderness and grazing lands, which currently entails the total backfilling of the open pit.

The table below highlights the opportunities and constraints associated with each of the four proposed options as part of the pit closure alternatives for the Tshipi Mine from both an aquatic and terrestrial ecological perspective.

Table 5: Summary of the Ecological Pro's and Con's pertaining to the proposed closure options.

Option	Aquatic Ecology		Terrestrial Ecology	
	Opportunities	**Constraints**	**Opportunities**	**Constraints**
Complete Backfill	• No risks of impacted water quality accessible to humans livestock and wildlife; and • **Not preferred from an aquatic ecological point of view but acceptable in light of the natural characteristics of the area.**	• Lost opportunity to create a surface water feature that can increase (although artificially) biodiversity and especially aquatic biodiversity in the area; and • **Not preferred from an aquatic ecological point of view but acceptable in light of the natural characteristics of the area.**	• Limited residual post-closure impacts to the receiving environment; • Landscape reinstated to that of pre-mining conditions; • Opportunity to rehabilitate and provide maximum land for grazing/wilderness use; • Re-introduction of protected plant species within the disturbed landscape; • Revegetation and rehabilitation will allow for the provision of terrestrial habitat for faunal species displaced as a result of mining activities; • Recreate habitat connectivity amongst the landscape whilst opening up new breeding areas previously lost; and • **Ecologically acceptable option.**	• Requires monitoring in terms of indigenous vegetation rehabilitation and alien plant species proliferation; • Single habitat creation, not maximising biodiversity potential: ○ Original biodiversity unlikely to ever be fully reinstated; and • Natural carrying capacity will never be truly reinstated to pre-mining levels; and • **Ecologically acceptable option.**
Partial Backfill	• No risks of impacted water quality accessible to humans livestock and wildlife; and • **Not preferred from an aquatic ecological point of view but acceptable in light of the natural characteristics of the area.**	• Lost opportunity to create a surface water feature that can increase (although artificially) biodiversity and especially aquatic biodiversity in the area; and • **Not preferred from an aquatic ecological point of view but acceptable in light of the natural characteristics of the area.**	• Landscape partially reinstated to that of pre-mining conditions; • Re-introduction of protected plant species within the disturbed landscape; • Revegetation and rehabilitation will allow for the provision of terrestrial habitat for faunal species displaced as a result of mining activities; • Opening up new breeding areas previously lost; and • **Ecologically not acceptable as does not allow for reinstatement of pre-mining analogue conditions nor does it provide for the opportunity to landscape and create new useable habitat.**	• Remnants of mining activities evident such as waste rock dumps); • Slope may be revegetated; however, steep slopes will not provide suitable grazing landscape for faunal species; • Single habitat creation, not maximising biodiversity potential: ○ Original biodiversity unlikely to ever be fully reinstated; and ○ Natural carrying capacity will never be truly reinstated to pre-mining levels. • Habitat connectivity will not be reinstated; • Alien plant species proliferation likely to be higher as indigenous species establishment will be limited; • Requires monitoring in terms of indigenous vegetation rehabilitation and alien plant species proliferation; and **Ecologically not acceptable as does not allow for reinstatement of pre-mining analogue conditions nor does it provide for the opportunity to landscape and create new useable habitat.**

Option	Aquatic Ecology		Terrestrial Ecology	
	Opportunities	**Constraints**	**Opportunities**	**Constraints**
Concurrent In-pit dumping only	• The EPL can be designed in such a way as to have extensive shallow areas and have some productivity which can support a level of biodiversity; • The EPL can be designed in such a way as to maximise habitat diversity and create areas where fish and other aquatic biota can successfully spawn; • Opportunity to create a surface water feature that can increase (although artificially) biodiversity and especially aquatic biodiversity in the area; and • **Deemed the preferred option from a freshwater resource management point of view.**	• Increased risk to people wanting to utilise the area due to falling and drowning; • Risk of poor quality water being unable to support an aquatic community of significant biodiversity value and diversity; • Risk of creating an eutrophic environment unable to support an aquatic community of significant biodiversity value and diversity; • Risk that persons utilising the EPL for fishing and a source of protein being exposed to excessive contaminants such as heavy metals; and • **Deemed the preferred option from a freshwater resource management point of view.**	• Creation of a multiple areas of habitat for utilisation through landscape reshaping; • Landscape partially reinstated to that of pre-mining conditions whilst providing for potential water resource in an otherwise water scare environment; • Creation of an EPL will result in an increased habitat diversity, thereby stimulating an increase in faunal and floral species diversity; • Partial backfill will allow for the creation of revegetated areas through adequate soil profiling of the Kathu Thornveld as well as a freshwater habitat maximising habitat provision in the area; • Possible new recreation area for local tourism activities which could be used to provide funding for long term ecological management activities/alien plant control activities; • Potential source of water for animals to drink from; • Creation of a new biodiversity hotspot, species breeding grounds and a source from which species could repopulate surrounding habitats; and • **Ecologically preferred option.**	• Remnants of mining will still be evident; • Extended timeline till EPL is created and functioning vs that of complete backfill habitat creation; • Arid climate of region will result in an extended timeline until the pit lake is created and functioning versus that of the complete backfill scenario. Worst case is that a suitable lake system may never be created; • Landscape only partially reinstated to that of pre-mining conditions; • Insufficient water level to enable use by faunal species; • Steep sides of pit and low water level may result in potential hazard for faunal species if they fall into the pit and cannot escape; • Rainfall dependant so water in pit may become stagnant and unsuitable for human/animal use/consumption; • Increased risk of additional long-term closure impacts and management requirements; and • Increased risk of alien plant proliferation as increased water resources will stimulate growth; and • **Ecologically preferred option.**
No In-Pit Dumping and No Backfill	• Option provides no foreseeable opportunities that would benefit the local ecology or environment. • **Ecologically not acceptable.**	• Lost opportunity to create a surface water feature that can increase (although artificially) biodiversity and especially aquatic biodiversity in the area since the EPL will be deep with steep sides and little habitat diversity; • Water will be well below natural ground level and thus isolated from the surrounding less affected environment; • Risk of creating an eutrophic environment unable to support an aquatic community of significant biodiversity value and diversity; • Risk that persons utilising the EPL for fishing and a source of protein being exposed to excessive contaminants such as heavy metals. and • Increased risk to people wanting to utilise the area due to falling and drowning; and • **Ecologically unacceptable option.**	• Option provides no foreseeable opportunities that would benefit the local ecology or environment • **Ecologically not acceptable.**	• Remnants of mining including mine residue dumps increasing latent footprint of impact; • No terrestrial habitat created post closure resulting in a permanent loss of grazing and habitat; • Longest timeline for pit to fill with water, most likely never fill to necessary levels due to the mine being located in a low rainfall arid zone; • No opportunity for the reestablishment of protected floral species such as *Vachellia erioloba and Vachellia haematoxylon*; • Likely to result in the highest levels of alien plant species proliferation as not resloping and reestablishment of indigenous vegetation will take place; • Highest levels of residual impacts to ecology; and • **Ecologically unacceptable option.**

6. DISCUSSION AND CONCLUSION OF OPTIONS ANALYSES

After undertaking a detailed analyses of the data gathered from the analogue sites, conclusions regarding the best closure option of the four proposed closure options was taken under consideration at this stage. It is the opinion of the ecologists that the proposed EPL will be of limited value, from a biodiversity resource management point of view, if not cogently designed and managed. This is largely due to the severe habitat and water quality limitations which could limit the diversity, sensitivity and abundance of aquatic macrophytes, fish and aquatic macro-invertebrates that can be supported as well as the ability for terrestrial vegetation to establish and the ability to create habitat and safe access to the water in the EPL by terrestrial fauna.

However, with correct design, the EPL does have significant potential as a comparative biodiversity support area for the surrounding region. The value of the EPL, from a conservation viewpoint has the potential to be significantly increased if the EPL is designed with ecological support criteria in mind and with specialist input into the design criteria by a suitably qualified team of ecologists. The key design criteria required to enhance the feature summarised in the points below which will be expanded upon if it is decided to design closure to include an EPL:

1. Pit water level;
2. Shaping of the adjacent terrestrial areas to allow safe access of fauna to the EPL;
3. Rehabilitation (including revegetation) of the terrestrial areas adjacent to the EPL;
4. Creation of ecologically productive shallows;
5. Creation of gravel beds and scree slopes for breeding habitat;
6. Construction of floating wetlands to promote the establishment of food webs and nutrient cycling as well as aquatic habitat;
7. Introduction of Desirable Fish Species; and
8. Measures to improve and manage water quality.

Assuming these design criteria can be met the outcome of the options analyses can be summarised as presented in the table below which ranks the options and provides a description of each. Should it not be possible to meet these criteria, complete backfill of the pit would be the most desirable outcome from a biodiversity resource management perspective.

Table 6: Summary of the ranking of each pit closure option from a biodiversity resource management perspective.

Desirability Rank	Scenario	Definition
1	Concurrent In Pit Dumping *	In pit dumping only (no post closure backfill) with formation of a partial pit lake and the rehabilitation of waste rock dumps concurrent with mining.
2	Complete Backfill	Backfill of the final pit void post mining to original ground level, before rehabilitation of the surface. [the current EMP approval]
3	Partial Backfill	Backfill of the final pit void post mining to a level just above the rebound water-table level, estimated to be approximately 50 m below original ground level, before rehabilitation of the surface.
4	No Backfill	No backfill of the pit either concurrent with mining or post mining i.e. all waste rock to surface dumps. The pit side-walls and end-walls will only be 'made safe'. [a hypothetical scenario]

***Assuming that in pit dumping will ensure shaped areas allowing safe access of fauna to the waterbody as well as shaping of the partial backfill material to ensure that the EPL has shallow productive areas with a euphotic zone and that additional rehabilitation criteria as guided by an appropriately qualified ecologist are applied. Should it not be possible to meet these criteria, complete backfill of the pit would be the most desirable outcome from a biodiversity resource management perspective.**

7. DESIGN REQUIREMENTS OF THE CONCURRENT IN PIT DUMPING CLOSURE SOLUTION

7.1 End Pit-Lake Design Criteria to Enhance Support of Aquatic Ecology

To ensure a sustainable system which supplies as enriching an experience as possible to its users as well as contributing to the biodiversity support and ecology of the area, suitable habitats should be created within the pit-lake, not only for the fish species to be introduced but for other species, such as water-birds, aquatic macro-invertebrates and potentially amphibians. The sections below present recommendations as to how this can be achieved. Furthermore, Section 7.1.4 provides detailed information on the construction of floating wetlands which will not only filter toxicants from the water but will provide cover and possible feeding sites for aquatic species and feeding and nesting sites for water-birds. The floating wetlands will also increase the productivity of the pit lake and improve the overall ecological functioning and biodiversity of the system.

7.1.1 Pit Full Level Maximisation

The pit-lake should be developed in such a way as to ensure that the lake is as full as possible without decanting to ensure that the pit-lake is ecologically connected to the surrounding area. This will allow fauna which need to utilise the water safer access to the water source. The scenario presented in the figure below should be avoided at all costs if the pit is to be utilised as a comparative biodiversity support area.

Figure 5: A Pit-lake that does not reach the crest making it ecologically isolated. This is to be avoided at all cost.

7.1.2 Creation of Shallows

Since the pit lake water level will rise very slowly, an attempt to ensure the continued availability of shallow habitats as the water level rises is deemed essential. This will ensure that productivity and ecological functioning in the pit lake is maintained as it fills. The benches along with the ramp roads must have habitat created along their lengths and the benches sloped to create this continuity as the water level rises.

One of the major constraining factors in the pit-lake will be the lack of shallow areas of substrate in the euphotic zone of the lake. Shallow areas in a pit lake are of particular importance as the shallower areas provide increased habitat and substrate within the euphotic zone of the lake thus increasing the productivity of the lake. With the pit expected to be very deep at steady state, the need to create shallows is considered essential. Any fairly shallow areas can be brought up to the recommended average depth of 0.6-1m for the euphotic zone through strategic backfilling. It is however recommended to improve efficiency and results that areas of less steep gradient within the pit are targeted. Refer to Figure 6.

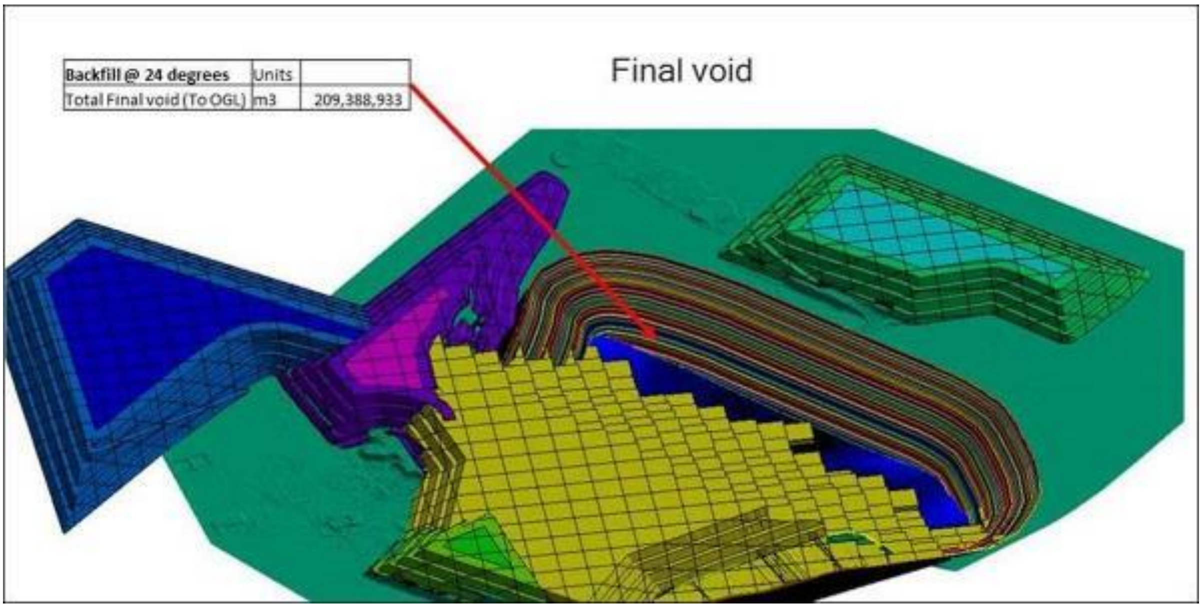


Figure 6: Conceptual layout of concurrent backfilling indicating the final void and position of shallow backfilled areas.

As much of these areas as possible should be created and a target of 10% of the pit lake being in the euphotic zone should be considered a Key Performance Indicator (KPI). As far as possible such areas should be spread around the edge of the lake.

A suitably qualified aquatic ecologist should be employed in a consultative capacity throughout the shaping and landscaping of the proposed pit-lake to ensure that the desired outcome is achieved.

7.1.3 Creation of Gravel Beds, Scree Slopes, Brush Reefs and Refugia

A vital component of all aquatic ecosystems is cover and habitat for aquatic fauna as well as aquatic vegetation. The dominance of smooth bedrock faces and bench bases in an open pit scenario provides very little habitat and cover for aquatic life. It is therefore of importance that a variety of microhabitats are created to allow for the establishment and success of a variety of aquatic species. To improve this condition the creation of gravel beds and scree slopes is strongly advised.

One important consideration in the creation of refugia is the provision of interstitial space of varying sizes. This can be achieved through the creation of gravel beds in the shallower portions of the pit-lake, which will provide small interstitial spaces for aquatic habitat for macro-invertebrates such as species of the family Gomphidae and Aeshnidae (order Odonata); and potentially species of the family Potamonautidae (order Crustacea), if introduced, as well as various species of Ephmeroptera and Trichoptera. Juvenile and small fish species, that are introduced, will also be able to utilise the created small interstitial space for cover while bigger, more mature fish can utilise larger interstitial spaces. This measure will greatly enhance the ecology of the system.

Brushwood reefs should also be constructed, in order to provide shelter for smaller fish species and ambush cover for larger predatory fish, if introduced and in general increase biological complexity, productivity and stability. The use of natural materials for the construction of brushwood reefs prevents the leaching of chemicals into the water and provides a surface for the growth of algae, an important food source for a number of recommended fish species (Section 2.1). These structures should be simple piles of brushwood weighted down with boulders as illustrated by Figure 7 below.

The creation of refugia should, where possible, be limited to the portions of the pit-lake which fall within the recommended maximum depth of 4m, to ensure their viability for use by aquatic species.

A suitably qualified aquatic ecologist should be employed in a consultative capacity throughout the shaping and landscaping of the proposed pit-lake.

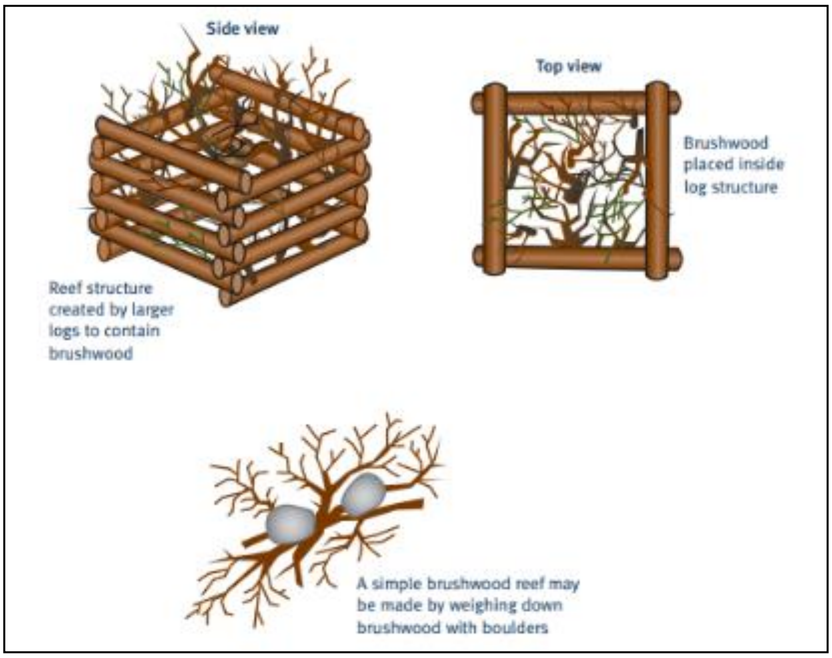


Figure 7: Brushwood structures for the purpose of habitat enhancement

7.1.4 Vegetation

It is recommended that vegetation growth within the pit-lake be encouraged. This is due to the fact that the pit-lake is expected to be stocked with forage fish species such as *Pseudocrenilabrus philander* and *Tilapia sparrmanii*, which are omnivorous and, especially in the case of *Tilapia sparrmanii*, prefer habitats with submerged and/or emergent vegetation. Aquatic vegetation may take a number of forms, namely;

- Submerged;
- Floating-leaved (attached);
- Free-floating; and
- Rooted emergent.

Figure 8 below, illustrates these vegetation types.

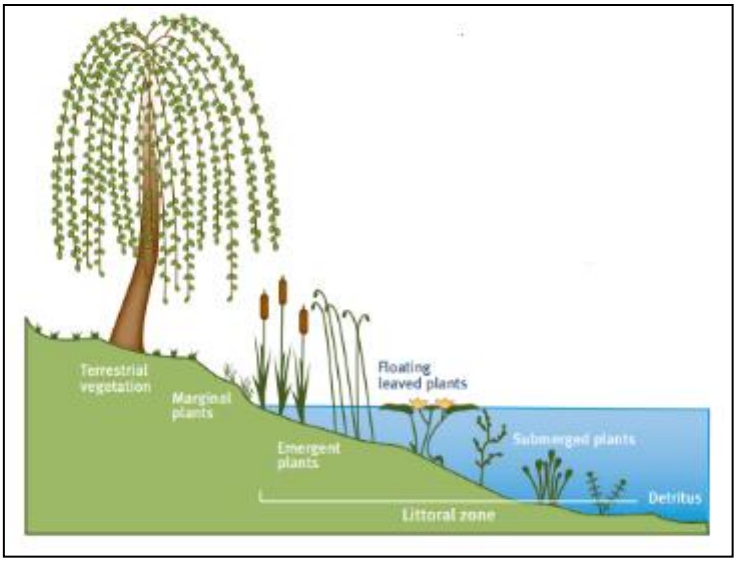


Figure 8: A cross-section of a lake edge, showing the different types of aquatic vegetation.

It should be noted that free-floating vegetation may occur anywhere on the surface of a waterbody and can become problematic and aesthetically unpleasing if the system becomes eutrophic.

The table below, adapted from Gerber *et al* (2004), gives some examples of vegetation commonly found in South Africa within each of these four categories. Those which are emboldened are indigenous to South Africa and thus are highly recommended for use in the pit lake.

Table 7: Common species per class of aquatic vegetation

Class	Species	Description
Submerged Vegetation	*Isolepis fluitans*	
	Lagarosiphon major	Good for permanent water bodies
	Potamogeton crispus	In the region
	Potamogeton pectinatus	In the region
	Potamogeton schweinfurthii	In the region
	Uticularia stellaris	Bladderworts, good for retaining water in dry periods
Floating-leaved (attached) Vegetation	***Aponogeton distachyos***	Adapted to growing in ponds and vleis which dry up in summer
	Nymphaea nouchali var. caerula	Found in the region
	Nymphoides thunbergiana	used as soil stabilizers
	Trapa natans	
Emergent: Broad-leaved	***Ludwigia adsendens subsp. diffusa***	
Narrow-leaved vegetation	*Cladium mariscus*	
	Cyperus marginatus	obligate wetland species
	Cyperus sexangularis	Facultative positive species
	Juncus lomatophyllus	obligate wetland species
	Phragmites australis	obligate wetland species
	Phragmites mauritianum	facultative wetland species
	Schoenoplectus brachyceras	obligate wetland species
	Schoenoplectus paludicola	obligate wetland species
	Typha capensis	obligate wetland species

Encouraging the growth of rooted aquatic vegetation within the pit lake will pose a number of challenges due to the steep slopes and extreme depths of the pit, as well as the very limited euphotic zone which is likely to occur. For this reason, the further construction of floating wetlands is recommended (refer to Section 7.1.5), as these will not only provide microhabitats for macroinvertebrates and cover for small fish as a result of roots growing through the wetland base and into the water but will also provide a food source as a result of debris entering the pit-lake.

7.1.5 Construction of Floating Wetlands

Under normal circumstances the pit-lake is likely to be devoid of vegetation due to the steep slopes of the pit and the extreme depths of the pit. There will be a specific limitation on emergent vegetation due to the very limited euphotic zone that is likely to occur in the pit. Most aquatic vegetation in the system would therefore have to be floating vegetation. Floating vegetation is unlikely to naturally establish very rapidly. In order to speed up the process it is deemed to be of critical importance that the mine develops floating wetlands in the pit-lake if the facility is to act at all as a comparative biodiversity support area.

Wetlands provide important ecosystem services, particularly in terms of the assimilation of toxicants and excess nutrients, and habitat provision for a wide variety of species. Not only could the inclusion of floating wetlands within the pit-lake assist in water quality management, but they may also attract a variety of wildlife to the pit-lake and surrounding area and enrich the experience users of the pit lake (if applicable).

The concept of floating wetlands has been implemented with great success on the Hartbeespoort Dam as part of the Harties Metsi A Me – My water Project. The artificial floating wetlands have been shown to create excellent micro-habitats and niche habitats for fish, aquatic macro-invertebrates and waterfowl. Figure 9 below present the food web supported by floating wetlands and Figure 10 presents aspects of functioning floating wetlands.

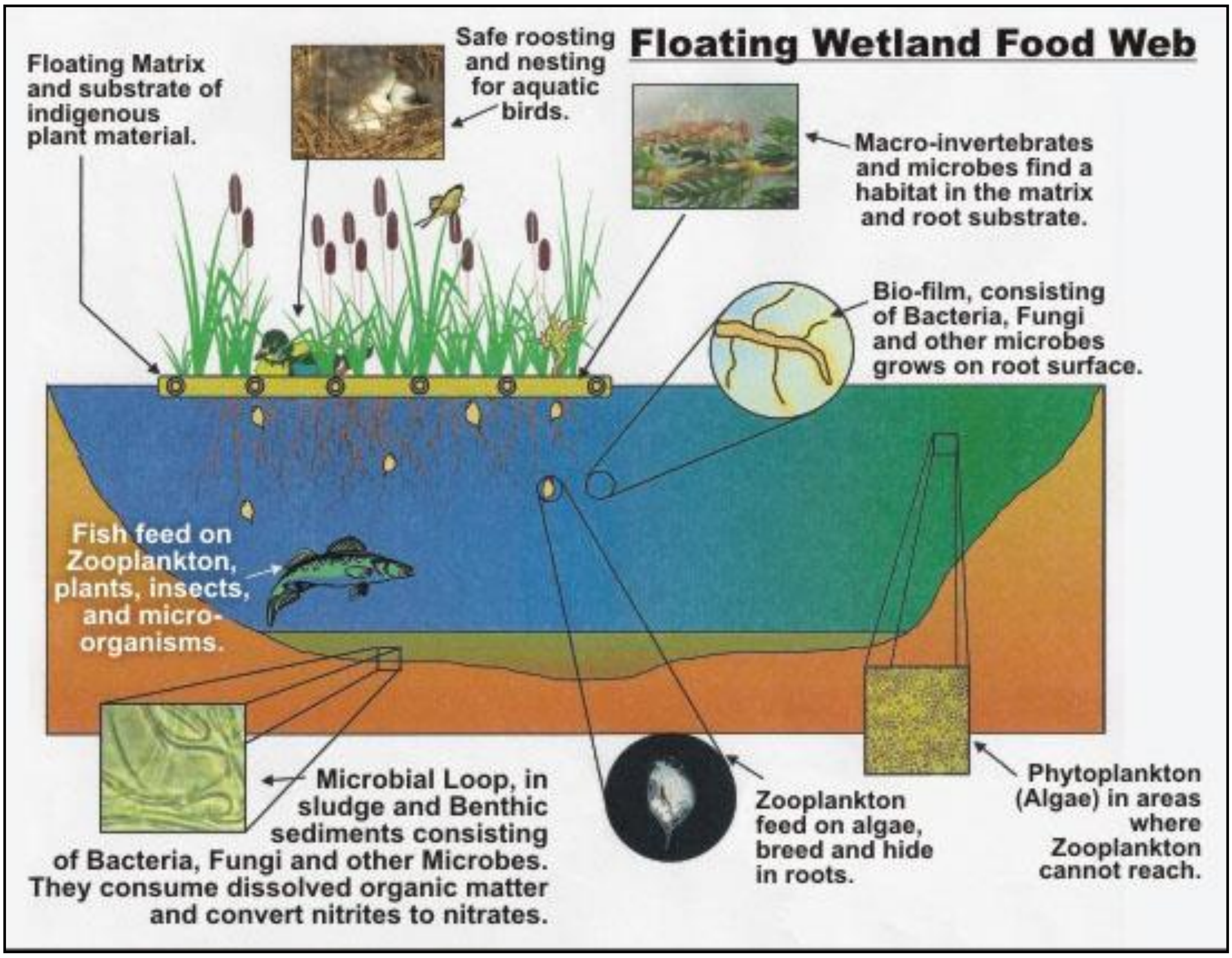


Figure 9: The Foodweb created by a floating wetland.

Figure 10: Floating wetlands on the Hartbeespoort dam (left) Niche habitat for waterfowl (right) (Harties Metsi A Me website) www.harties.org.za .

Materials required

After extensive testing and refinement by Wright *et.al*. 2017, the following materials were found to be most suitable in terms of cost-effective and quality construction of floating wetlands:

- 30mm Tremnet;
- Geojute or coir cloth;
- 4mm Tremnet;
- High-density SPX33 flotation foam noodles;
- Nylon net/netting;
- Cable ties;
- Nylon string; and
- Carabiners.

Further details on the construction of the floating wetland utilizing the above materials can be found below.

Construction process

The recommended floating wetland construction process, as presented by Wright *et al.* (2017), utilizing the materials listed in Section 2.4.1 above, is outlined in Table 8 below. It should be kept in mind that completed floating wetlands are very heavy, and thus construction should take place as close to a safe entry point to the waterbody as possible.

Table 8: Method of construction for floating wetlands

Method	Picture
Step 1: Construction of the base and frame	
➢ Trim the 4mm Tremnet sheets into the desired size and shape (multiple sheets can first be joined using cable ties or nylon string to create a large enough sheet if required). Any shape can be utilized, although an irregular shape is recommended for a more natural appearance. No size guidelines are available, but it should be kept in mind that the wetland needs to be small enough to maneuver into the waterbody post-construction yet large enough to support a fair diversity of plants and allow space for utilization by water birds. ➢ Once the Tremnet sheet base has been cut out, the high-density SPX33 flotation foam noodles can be folded and secured along the edge of the base, being fixed in place using cable ties. The foam noodles should lie on top of the base, not next to it. ➢ A grid can then be formed across the remainder of the base by cutting the foam noodles to size and attaching them using cable ties. The more noodles used, the more weight the wetland will support, although sufficient space should be allowed between the noodles for the placement of wetland plants (see Step 5).	

Step 2: Covering of the frame	
➢ Cover the upper surface of the frame in Geojute or coir fibre. The edges of the cloth should be long enough to wrap around the boundary foam noodles. ➢ The material can be secured to the foam noodles using cable ties.	
Step 3: Placement of anchorage network for plants	
➢ Cut the 30mm Tremnet to fit inside the foam noodle boundary frame. ➢ It can then be secured to the noodle framework using cable ties.	

Step 4: Attachment of anchor points	
➢ Create loops around the boundary of the floating wetland for the attachment of anchor points using cable ties attached to the boundary foam noodles. No guidelines are available for the number of anchor points, but flow within the waterbody, exposure to wind, and the necessity to keep the floating wetland anchored away from structures such as boat launch sites should be considered. ➢ Tie nylon rope to the anchor structure (such as netting bags filled with rocks) and attach a carabiner to the other end of the nylon rope. Ensure the rope is long enough for the anchor to reach to base of the waterbody at the point at which the wetland is expected to be anchored. ➢ The anchors can be attached to the anchor loops via the carabiners once the wetland has been positioned within the waterbody, in order to avoid adding unnecessary weight to the structure before relocation.	

Step 5: Planting

- Position the selected wetland plants (see Section 2.4.2 for species selection) on the upper surface of the floating wetland, ensuring you leave enough space for growth between individual plants.
- Remove the plants from their pots and insert the roots through the 30mm Tremnet layer, leaving as much soil attached as possible.
- Additional structure, such as branches and shelters for water-birds, can be added at this time too.
- If the wetland is very large, it may be more suitable from a weight-limitation perspective to plant the middle of the wetland on dry ground, and only plant the edges once the wetland has been placed within the waterbody.

Step 6: Placement of the floating wetland

- Once the wetland has been placed within the waterbody and all planting has been completed, it can be towed to the desired position within the waterbody.
- The anchors can then be set, keeping in mind that water levels may rise and fall when setting the anchor length.
- It is recommended that the wetland be covered with fine netting until the plants have become established, in order to avoid damage by water-bird grazing and nesting activities.

Suitable plant species

The wetland plant species listed below are easy to grow and are suitable for use on floating wetlands. They have been listed in order from what is considered high suitability for inclusion on these particular floating wetlands to lower suitability, based on factors such as natural distribution, use for wildlife and aesthetic value. All species may, however, be utilised here.

Table 9: Plant species suitable for use in the construction of floating wetlands.

Species	Description	Picture
Phragmites australis	Also known as the common reed, *Phragmites australis* is an indigenous obligate wetland species with a widespread distribution across South Africa, including Gauteng. It is a perennial grass-like plant growing up to 4m in height, offering shelter and nesting material for birds and other animals. It can be easily propagated by floating stems on water until they sprout at the nodes.	
Juncus lomatophyllus	This is a spreading perennial plant with a maximum height of approximately 0.8m. It is an endemic obligate wetland species with a widespread distribution across South Africa, including Gauteng Province. The plant is utilised as a food source by herbivorous species.	
Isolepis prolifer	*Isolepis* species are widespread throughout South Africa and, although their highest concentrations are found in the Western Cape, they have also been reported across Gauteng.	

Species	Description	Picture
Cyperus congestus	The dense flat-sedge is a perennial sedge which is widespread across South Africa. It is a grass-like plant with a short, thick rhizome which grows to approximately 1m in height.	
Cyperus sexangularis	The bushveld sedge is a robust clump-forming sedge found naturally within the Gauteng region, as well as in the North-West and Mpumalanga. This sedge is capable of growing within water and is recommended as being an ideal species for rehabilitation purposes.	
Zantedeschia aethiopica	Commonly referred to as the arum lily, *Zantedeschia aethiopica* is restricted to the African continent with a distribution within South Africa across the Western and Eastern Capes, Kwa-Zulu Natal, Mpumalanga and the Northern Province. Although not naturally found within Gauteng, the arum lily is an aesthetically pleasing plant of importance for insects, frogs and birds, and so could be considered a viable species for inclusion on floating wetlands within the residential development.	

Species	Description	Picture
Berula erecta	The lesser water parsnip has a widespread distribution across a number of countries, including South Africa. Although growing easily in a wide range of freshwater habitats and displaying attractive white flowers, this species is toxic and capable of causing death to grazing animals. As such, it is not recommended for use here	

7.1.6 Introduction of Desirable Fish Species

Fish are unlikely to rapidly colonise the pit-lake through natural processes, if at all, especially due to the remote location of the pit in relation to natural perennial water bodies in the area. Although fish may be introduced to the system through dispersal by natural agents such as avifauna it is considered likely to occur very slowly, if at all.

To enhance the value of the proposed pit-lake as a comparative biodiversity support area it is recommended that the more desirable fish species, which are suitably adapted to lacustrine systems, be introduced to the system. The following key species should be introduced:

Table 10: Fish species that should be introduced into the pit-lake

SPECIES NAME	COMMON NAME	INTOLERANCE RATING
Barbus paludinosus	Straightfin barb	1.8
Barbus unitaeniatus	*Longbeard barb*	1.7
Oreochromis mossambicus	Mozambique Tilapia	1.3
Labeobarbus Aeneus	Largemouth Yellowfish	3.6
Labeobarbus Aeneus	Smallmouth Yellowfish	2.5
Gambusia affinis	Mosquitofish	2.0
Labeo capensis	Orange river mudfish	3.2
Pseudocrenilabrus philander	Southern mouthbrooder	1.3
Tilapia Sparrmanii	Banded Tilapia	1.3

Consideration could also be given to introducing the threatened fish species *Labeobarbus kimberleyensis* (Largemouth yellowfish) which is considered to be vulnerable by the IUCN and is endemic to the Vaal-Orange river systems. If the proposed pit-lake can support this species it may form a valuable tool contributing to the conservation of this species of fish. A suitably qualified aquatic ecologist should be employed in a consultative capacity when introduction of fish species is to take place.

There is a possibility that *Micropterus salmoides* (Black bass) will be introduced into the system. This may occur through natural dispersion agents such as avifauna, however sport anglers may introduce the fish to the system if the conditions in the dam are suitable for recreational angling. This should be avoided at all costs as these fish will have a large impact on any aquatic fauna which become established in the system if the system is to be managed as an ecological hotspot. Management measures should be implemented in order to prevent this from occurring. If the objective is to have the lake used for sportfishing, the need for this control will fall away.

7.1.7 Measures to Improve Water Quality

Predicted water quality for the pit lake, as the pit fills is varied with most elements predicted to be present in low quantities although mercury, lead, copper, fluoride, selenium and zinc may become problematic along with high salt loads and high nitrate concentrations which in turn are likely to lead to eutrophication. In order for the pit lake to function effectively the water quality in the system needs to be as good as possible it is deemed essential that measures be implemented to ensure that water quality is as high as possible. It is critical that monitoring of water quality is undertaken to ensure that adaptive management of the rehabilitation associated with the end pit lake can be implemented. Included in this monitoring must be toxicity testing on four trophic levels at a minimum of six (6) monthly intervals.

7.2 Design Criteria and Methods to Enhance Support Of Post Closure Terrestrial Ecology

In order for the pit lake to function effectively as part of the greater terrestrial ecosystem it is imperative that the terrestrial areas adjacent to the lake are sloped and profiled so as to create flat and gently sloping areas which can be suitably revegetated in line with the surrounding Kathu Thornveld habitat. This will ensure that sufficient terrestrial habitat is located adjacent to the pit lake, supporting faunal species through habitat and food resource provision. This will ensure that an interconnected ecosystem between freshwater and terrestrial is developed and maintained.

The sections below highlight the various actions needed in order to recreate and rehabilitate the pit lake and surrounding topography to an acceptable degree in which natural ecological processes can take over and where species diversity, both fauna and flora, can naturally increase and self-manage.

7.2.1.1 Topography and Topsoil Reinstatement

Prior to any vegetation rehabilitation plans, it is imperative that a clear and cogent plan be developed in order to, as far as possible, recreate the natural topography in line with the surrounding natural environment. In addition to this, it must be ensured that the surrounding areas be rehabilitated to have a suitably deep enough topsoil covering to allow for vegetation re-establishment i.e., ensuring that the effective rooting depth of the soil is aligned with the vegetation to be used during rehabilitation activities. In addition to ensuring effective rooting depths are met, it must be remembered that the topsoil layer (0-25 cm) that is removed during mining is important as it contains nutrients, organic material, seed, and communities of micro-organisms, fungi and soil fauna. The biologically active upper layer of soil is fundamental to the development of soils and the sustainability of the entire ecosystem. In addition, topsoil depths can be varied across the rehabilitated areas in conjunction with the design and planned vegetation cover promoting habitat and topographical diversity.

When planning the rehabilitation activities, it must be understood that the current mining activities and movement of heavy machinery will have resulted in increased levels of soil compaction which poses a serious problem. The compacted soils often lead to increased surface water runoff and decreased water penetration/ingress into the topsoil. Additionally, large areas of hardened/compacted surfaces will have very little vegetation cover, resulting in increased runoff and erosion.

Taking the above into consideration, the following recommendations are made in terms of soils and topography, with reference to best terrestrial ecological fit for the area:

- All hardened surfaces will have to ripped/scarified in order to allow for the increased ingress of moisture as well as the development of floral species root systems;
- Soils are to be ripped in accordance with the landscape and revegetation plan, ensuring that soils are not ripped to unnecessary depths so as to limit erosion and surface soil runoff during high rainfall events;
- Topsoil is only to be used for rehabilitation activities and is not to be used for any other processes or needs other than this;
- In areas, notably the remaining waste rock and discard dumps, erosion is likely to be a problem. In this regard it must be ensured that the slopes are adequately secured through the use of netting or matting (GeoJute or Bio-Jute) to protect the soil surface until suitable vegetation cover has established. The netting material helps protect the soil from wind and water erosion, and the required rehabilitation plant material can be installed by making small incisions for planting. The netting is biodegradable and will eventually break down and form a mulch layer;
- Slopes should not exceed 18º incline angles as far as possible with all re-shaped areas should resemble the pre-construction landscape as closely as possible. This is particularly important in the areas indicated by points A, B and C in Figure 12 below;
- It is recommended that these areas be further levelled (indicated by arrows in Figure 12) and smoothed in order to align further with the surrounding and pre-mining landscape, allowing for a better ecological transition between the rehabilitated areas and the surrounding natural veld areas;
- By decreasing the numbers of elevated terrain units, it will automatically decrease the risk of surface water runoff, erosion and downslope sedimentation. In addition, the revegetation success rate is likely to increase as a result of this, as plant recruitment is less effective on sloped areas due to plants natural susceptibility to rain and wind erosion in newly established landscapes;

- To ensure the overall suitability of the landscape for faunal species in terms of area accessibility, it is important to consider the species that naturally occur in the region and that will likely utilise the water resource made available by the lake conditions;
- In this regard it is imperative to ensure that the overall topography (area encircled in Figure 12) associated with Point D on the image is not prohibitive to species movement and access, notably to and from the water edge;
- In addition to the above, it is recommended that the topography at Point B is further levelled and pushed into the open-pit void simulating the landscape proposed as indicated at Point D. This will ensure better habitat connectivity and allow for greater movement of faunal species;
- In this regard incremental terraces are to be used; however, these must be dynamic and not generic. Dynamic terraces entail the stratified use of varying terrace types (size and slope) across the encircled area, thereby creating terrain diversity, a more natural landscape effect and better use of the area for faunal and floral species. Such terrace design combined with the proposed revegetation/landscape plan can be used to efficiently and effectively utilise the available topsoil by creating areas of both deep and shallow soil structures as required by different plant species (effective rooting depths); and
- When designing the pit lake and surrounding topography, it is imperative to ensure that the surface water is accessible, even during periods of low rainfall/ water retention in the pit lake. At all costs the below pictured scenario must be avoided (Figure 11).

Figure 11: Pictured above the "Big hole" in Kimberly, an example of what must be avoided in terms of pit lake development.

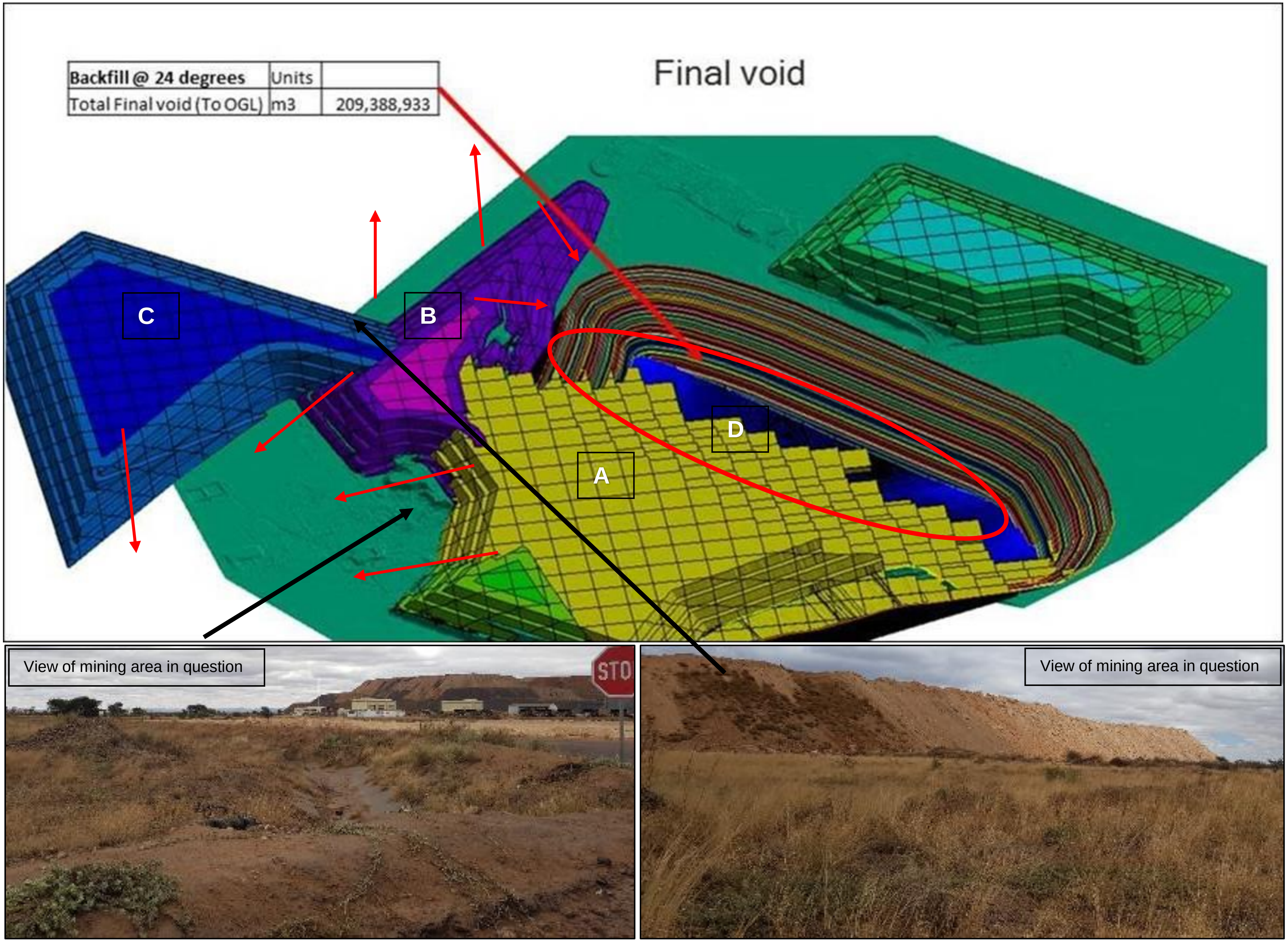


Figure 12: Conceptual layout of concurrent backfilling with arrows indicating recommended additional landscape smoothing.

7.2.2 Re-vegetation and floral characteristics

Revegetation is a process undertaken whereby floral species are established in areas that have previously been cleared, in order to restore and reclaim the lost habitat, ideally to a similar condition of that prior to mining conditions. One of the most significant issues facing rehabilitation is that of the establishment of a sustainable, self-productive ecosystem that is able to function without continued anthropogenic intervention (irrigation, fertilisation or re-seeding). Habitat restoration processes are often slow, taking decades and the final community of plants may not be the most desirable, notably when unmanaged. As such, a clear and concise revegetation plan must be in place in order to avoid such a scenario as far as possible. Re-vegetation may be achieved by three main techniques, namely planting of trees and shrubs, direct seeding, or by self-regeneration. It is important that the mine starts with trail runs on these aspects as soon as possible in order to develop a proven working and rehabilitation technique that can be implemented during the closure phase, so as to avoid timely and costly mistakes.

Topsoil availability is a major consideration when re-vegetation activities are being planned, as insufficient quantities will limit the degree to which an area can be revegetated successfully. Analysing the chemical properties of the soil and comparing that to neighbouring natural areas can be helpful in directing possible soil amendments (addition of fertilisers, organic composts or lime) as well as guiding species selection. A well-prepared and planned site will yield the most suitable conditions for plant germination while promoting the long-term success of the re-vegetation process.

7.2.2.1 *Rescued and relocated plants*

Revegetation should utilise species that are endemic to the area, including plant species that were rescued as part of a floral rescue and relocation plan at the outset of mining activities, unless these species have subsequently been relocated and planted in other areas outside of the mining footprint. Plants that have already been relocated to other areas are to remain there and not be removed and replanted again for the revegetation purposes. In the event that rescued plant species were placed in a nursery environment for future rehabilitation activities, it is important to take note of the following guidelines when using these plants for revegetation:

- In the area where replanting is to occur, dig a hole which is slightly larger and deeper than the plant's root structure;
- Place the plant in the hole and ensure that it is deep enough that the roots are covered;

- When placing the plant in the hole, it is recommended that as far as possible to retain the existing soil around the root structure;
- Replace enough soil in the hole to cover the roots and compact the soil to secure the plant in the hole. If necessary, use more soil and compact again;
- Make a depression around the plant with a spade such that water will drain towards the plant;
- Do not plant the plants in straight lines, but rather randomly as in the natural environment; and
- Ensure that planted areas are sufficiently watered in order to ensure their survival, notably in the early phases of germination, but be careful not to overwater the plants as this could lead to the rotting of the roots as well as erosion of the soil surface.

7.2.2.2 Reseeding alternatives (Collection vs premix*)*

Seed collection is an important aspect of rehabilitation work and is one of the most cost-effective ways to collect indigenous plant species. The collection of such seeds from the surrounding natural habitats is also important as the seeds from perennial plant species are often poorly represented in the topsoil layer. Timing of seed collection is important as the collection of underdeveloped or unripe seeds will lead to unsuccessful germination of the seeds when replanted. Additionally, it may be necessary to collect seeds more than once a season in order to obtain a suitable representation of floral species. Seeds collected should be dried and placed in paper bags and stored in cardboard boxes in a cool dry, keeping in mind that the viability of the seeds will reduce with time. As such, it is recommended that seeds be collected in the year leading up to the desired re-seeding activity to ensure the maximum viability of the seeds collected. In order to ensure this process has the highest rate of success, it is recommended that seed collection should be undertaken/overseen by a suitably qualified specialist who is familiar with the various seed types associated with the plant species in the area.

An alternative to the manual collection and storage of seeds, notably grass seeds, is to utilise the Mayford Biosome Sweet and Mixed Bushveld seed mix which has been designed for rangeland improvement/revegetation in areas where summer rainfall is between 250 and 625mm per annum. This is a viable alternative to the above collection method as it is likely to contain a higher species diversity, has been properly collected and stored, is weed free and is likely to have a higher germination rate than that of the collected seeds.

Even if the second option of a premix seed bank is opted for through Mayford, it is recommended that seed collection from small shrubs, trees and succulents still occurs. The seeds collected from these species can be scattered into the topsoil during reseeding activities. This will ensure that plant growth in the revegetated areas is not solely restricted to graminoid species and will ensure floral species diversity in the revegetated areas.

7.2.2.3 Reseeding timing

The timing of reseeding activities is imperative as this will ensure a high rate of germination and plant establishment. As far as possible reseeding of graminoid (grass) species should occur in the winter months, allowing for seeds to settle into the soil surface and establish prior to the onset of the first rains. However, this should be guided by a rehabilitation specialist who understands the region, the vegetation and rainfall patterns. When reseeding areas, two methods can be used, manually hand seeding an area or hydro-seeding. Such methods will be largely dictated by the site, topography and accessibility of the areas to be reseeded. The on-site Environmental Control Officer (ECO) or rehabilitation specialist should determine the best approach on an area by area basis.

7.2.2.4 Alien and Invasive Plant Control

Tshipi Borwa Mine has an existing Alien and Invasive Plant (AIP) species management and control plan that details areas and species of concern and control methods. This plan should be updated closer to the time of closure so as to best facilitate the control of AIP's in the context of the closure activities, as well as to provide further guidance as to post-closure AIP control requirements. The continued implementation and updating of the AIP control plan is imperative as AIP species in general have a higher recruitment rate than indigenous species, notably in disturbed areas. Should uncontrolled AIP establishment be allowed to occur in the revegetated areas, these species will compete for space and water resources with indigenous species. Such species are often faster growing, have a higher rate of seed dispersal and germinate faster than indigenous plant species, which will lead to an undesirable plant community dominated by AIP species post rehabilitation. The rectification of this scenario will be labour and cost intensive, and greatly extend the overall rehabilitation timelines beyond that of the mine closure plan.

7.2.2.5 Floral Habitat Goals

Prior to any reseeding activities, it is imperative that a well thought out plan is in place which clearly defines and describes the types of habitat that are to be created in around the proposed pit lake. Such a plan must also take into account the proposed topographical rehabilitation activities and layering of topsoil (depths), as this will also guide the proponent as to which species can be seeded within various areas. Vice versa, should the plan call for certain areas to be planted with larger woody species, it is important to ensure that when topsoil is being laid, that in these areas the topsoil depth is increased to ensure the soils are suitably deep enough to sustain the deep root structures of the woody species.

The overall rehabilitation and replanting plan should ensure that the habitat recreated around the pit lake is, as far as possible, similar to that of the surrounding natural areas and that of the vegetation type, i.e. the Kathu Thornveld vegetation type (Mucina and Rutherford, 2018). Depicted below are images indicating the ideal goals (conceptual) that should be aimed for in terms of short, medium and long terms revegetation goals.

Figure 13: Images illustrating short (Image A) to medium (Image B) term revegetation goals.

Figure 14: Images illustrating long term revegetation goals surrounding the pit lake.

Table 11 below indicates plant species that have previously been recorded in the natural areas surrounding the mine as per studies undertaken by Scientific Terrestrial Services in 2017 (STS 170075). This species list can serve to guide the proponent as to which species can be used during revegetation activities in order to attain a similarity between the revegetated areas species composition and that of the surrounding veld. Not all the below species will be viable for initial rehabilitation activities, and many will take years to establish themselves. The appointed specialist must plan for this and develop objectives detailing the short, medium and long term goals in terms of species recruitment and grass sward cover.

Table 11: Floral species identified in the surrounding habitat of the mining area

Grass species	Forb species	Tree/Shrub Species
Stipagrostis amabilis	*Ammocharis coranica*	*Vachellia hebeclada*
Stipagrostis uniplumis	*Aptosimum elongatum*	*Lycium hirsutum*
Eragrostis pallens	*Chrycosoma ciliata*	*Asparagus laricinus*
Eragrostis trichophora	*Dimorphotheca sp.*	*Grewia flava*
Melenis repens	*Felicia muricata*	*Senegalia mellifera* subsp. *detinens*
Anthephora pubescens	*Gnidia polycephala*	*Vachellia erioloba*
Pogonarthria squarrosa	*Helichrysum cerastioides*	*Vachellia haematoxylon*
Cynodon dactylon	*Melolobium candicans*	*Ziziphus micronata*
Aristida meridionalis	*Nolletia arenosa*	
Cenchrus ciliaris	*Pentzia globosa*	
Aristida congesta	*Pollichia campestris*	
Enneapogon cenchroides	*Pteronia glauca*	
Eragrostis lehmanniana	*Senna italica* subsp. *arachoides*	
Hyparrhenia hirta	*Tribulus zeyheri*	
Brachialis nigropedata	*Lophiocarpus polystachyus*	
Centropodia glauca	*Elephantorrhiza elephantina*	
Schmidtia pappophoroides		

Revegetation of the banks and immediate landscape adjacent to the water surface should be done using grass species and small shrubs that are tolerant to fluctuating water levels, so as to ensure continued bank stability. Should the proponent wish, under the guidance of a suitably qualified specialist, to incorporate riparian zones in areas along the pit lake, it is recommended that tree species such as *Vachellia karoo* and *Ziziphus mucronata* be used in patches along the bank to create stability. Further up the bank slopes species such as *Vachellia hebeclada, Grewia flava* and *Vachellia haematoxylon* can be incorporated to create small woodland areas. The establishment of *Vachellia erioloba* will take an extended period of time as these are slow growing species. It is recommended that saplings of *Vachellia erioloba* be obtained from a registered grower or nursery and used during the rehabilitation process. Saplings should be used as this will ensure a higher survivability rate.

The images below provide guidance as to what the habitat and slopes surrounding the pit lake can be designed to. These images are illustrative only and the end result of the pit lake slope and habitat will have to be determined following further design and engineering planning. The images below depict a lake system with a seasonally fluctuating water level, as will occur with the proposed pit lake.

Figure 15: Images illustrating possible vegetation characteristics surrounding the pit lake.

7.2.3 Faunal Habitat and the Pit lake

Physical relocation of faunal species is not always a viable option, is costly and furthermore requires areas to be fenced to control species movement. As such, the relocation of faunal species with the particular intent of increasing faunal diversity and abundance as part of the pit lake development and rehabilitation activities is not a viable option. Natural relocation and faunal dispersal will be relied upon in order to repopulate the rehabilitated areas. Currently the Tshipi Borwa Mine is fortunate in that it is surrounded by large natural open spaces, inhabited by a high diversity and abundance of faunal species. These species will over time relocate to and inhabit that rehabilitated areas, provided the habitat is suitable. As such, in order to ensure that faunal species use of the area, it is imperative that the overall habitat and vegetation composition is such that it will provide habitat and food resources to faunal species. Poor habitat quality and a high abundance of alien plant species will result in a low faunal species abundance and diversity, and failure of the rehabilitation objectives in terms of recreating viable habitat similar to that of pre-mining. In addition, the water contained in the pit lake will provide a much needed and scarce resource to the otherwise arid environment, which will be discussed further below.

7.2.3.1 Water *Resource - Pit lake*

One of the largest concerns when proposing mine closure options is that of the supposed water quality of the pit lake. The quality of the water has a direct impact on the faunal species that will drink from the water and if it will in the long run be safe for animal consumption. Water that is too brackish or acidic will likely be avoided by faunal species, other than some invertebrates of the Odonata Family (Dragonflies and Damselflies). Water of suitable quality is essential not only for wildlife consumption, but for instream aquatic species. In order to ensure that the pit lake functions as a complete ecosystem, the water quality needs to be of sufficient standards so as to support a viable instream aquatic community but also a terrestrial community who will rely on the surface water for breeding (Insects and amphibians) as well as for consumption (Mammals and avifauna).

The water quality in the pit was modelled by SLR over a period of 200 years and compared to the maximum allowable levels according to the Department of Water and Sanitation (DWS) for livestock watering. The model was then rerun considering the effects of phytoremediation using floating wetlands on water quality over the same time period. By and in large the levels are below that of the allowable maximums for livestock with the exception of mercury (Hg) which starts exceeding the maximum levels after 100 years and after 200 years with phytoremediation by floating wetlands. This is of considerable concern as this is a highly toxic metal and will lead to the fatality of numerous faunal species unless appropriate measures are put in place to mitigate this. However, it is important to note that the mercury concentration is theoretical because it is not detectable in the groundwater around the site and hence the limit of detection is used in the modelling and, it may never be detectable in the pit lake water over. time Nitrate (NO3) and Selenium (Se) levels start exceeding allowable levels whilst the overall TDS begin exceeding maximum allowable tolerances after 100 years and continue to increase however with phytoremediation using floating wetlands these water constituents are adequately managed to support livestock watering.

7.2.3.2 Faunal Species

As discussed above, it is not practical to relocate faunal species into the area as part of the rehabilitation plans. As such, natural dispersal and movement of species will form the basis of faunal species recolonization. In order to ensure this, it is important to ensure that access to and through the site is not hindered, and that no manmade or natural barriers exist that will limit species movement. This relates back to Section 7.2.1, where the overall topography and accessibility was discussed at a topographical scale. This is important as larger mammals as well as avifauna will be able to move over elevated ground (old waste rock dumps) with relative ease in order to access the pit lake, however smaller species and those that are slower moving (tortoises etc) may in such instances not be able to access the pit lake due to terrain constraints. If given the option, larger mammal species may also seek out an easier alternative and avoid the pit lake altogether, should the terrain result in an increased level of energy expenditure or risk due to steep slopes.

Mammals

Mammal species are an integral part of ecosystems, browsing and grazing on plant species, fertilising the soils through dung production all whilst helping to facilitate seed dispersal of plants. A further factor that needs to be considered is that many of the mammal species in the Northern Cape region, especially the ones that have been previously recorded in the mining property (Table 12 below) are largely water independent species. Many of these species obtain their moisture requirements from their diet (food resources) or are able to go for extended periods of time without having to supplement their moisture intake from standing waterbodies. Such species will likely be drawn to the pit lake not only due to the presence of water, but largely due to the availability of habitat and food resources. As such, although the pit lake will form an important source of water, mammal species may limit their usage of the pit lake area if the terrain (access constraints) and/or the habitat therein is unsuitable. A holistic approach in terms of water resource and terrestrial habitat creation needs to be undertaken in order to ensure the overall suitability of the Pit Lake and rehabilitated mining areas for mammal species.

Table 12: Mammal species identified in the surrounding habitat of the mining area

Scientific name	Common Name	IUCN Red List Status
Sylvicapra grimmia	Common Duiker	LC
Galerella sanguinea	Slender Mongoose	LC
Hystrix africaeaustralis	African Porcupine	LC
Lepus saxatilis	Scrub Hare	LC
Galerella sanguinea	Slender Mongoose	LC
Cryptomys hottentotus	Common Mole-rat	LC
Tragelaphus strepsiceros	Kudu	LC
Phacochoerus africanus	Warthog	LC
Raphicerus campestris	Steenbok	LC

In addition to the species listed above, provided that revegetation is successful and that the habitat created is of suitable quality, it is possible that species such as H*yaena brunnea* (Brown Hyaena, NT) and the elusive and seldom seen and elusive *Proteles cristatus* (Aardwolf) and *Orycteropus afer* (Aardvark) may habitat surrounding the pit lake for foraging.

<u>Avifauna</u>

Birds are excellent flagship species and valuable indicators of the environment and habitat. Areas of high bird species richness and abundance are often abundant in other forms of biodiversity. The presence of birds indicates a healthy environment and thriving ecosystem.

The design of the pit lake will not require the introduction of avifaunal species into the ecosystem since avifauna will migrate to the area based on the suitability of habitat created. The time taken for avifauna to colonise the rehabilitated areas will be less than the time taken for them to adapt to the current disturbed environment created as a result of the mining activities. The bird species that recolonise and utilize the pit lake and surrounding rehabilitated habitats can therefore be used as an indication of the success of the rehabilitation activities and the pit lake

The shallow littoral zone (including the banks) of the western and southern section of the pit lake may potentially provide important breeding and foraging habitat to various species of waterfowl and other wading species. Water serves as an essential foraging and transport medium for certain species, and without water, these species would not be able to feed, nest and find shelter.

Creation of reed bed sections along the edge of the pit lake can create vital habitat for species such as herons and weavers since they favour the presence of reeds along water sources. Reedbeds also harbour vast arrays of insects and small mammals, which act as food source to raptors and insect-eating species. Other avifauna such as egrets and plovers often select for area where there is the presence of sand and/or mud in a suitable habitat along lake and riverbeds. The sand along the edges of the pit lake will provide a medium upon which to forage, place a nest and to rest.

In addition to below listed species, provided that rehabilitation activities are a success, protected species as per the Threatened or Protected Species list (NEMBA) such as *Neotis ludwigii* (Ludwig's Bustard) and *Ardeotis kori* (Kori Bustard) may recolonise and utilise the pit lake area for nesting and foraging, notably the recreated grassland and shrublands surrounding the lake area.

Table 13: Avifaunal species observed in the surrounding habitat of the mining area

Streptopelia capicola	Cape turtle-dove	LC
Pycnonotus nigricans	Red-eyed Bulbul	LC
Serinus flaviventris	Yellow Canary	LC
Passer melanurus	Cape Sparrow	LC
Streptopelia capicola	Cape Turtle-Dove	LC
Sporopipes squamifrons	Scaly-feathered Finch	LC
Spreo bicolor	Pied Starling	LC
Saxicola torquata	African Stonechat	LC
Anthus cinnamomeus	African Pipit	LC
Cisticola fulvicapillus	Neddicky	LC
Elanus caeruleus	Black-shouldered Kite	LC
Tockus nasutus	African Grey Hornbill	LC
Dicrurus adsimilis	Fork-tailed Drongo	LC
Hirundo fuligula	Rock Martin	LC
Parus cinerascens	Ashy Tit	LC
Batis pririt	Pririt Batis	LC
Sigelus silens	Fiscal Flycatcher	LC
Emberiza flaviventris	Golden-breasted Bunting	LC
Parisoma subcaeruleum	Chestnut-vented Titbabbler	LC

Amphibians

Most frogs require suitable habitat in both the terrestrial and aquatic environments, with some species proving to be largely water independent, however they need to return to bodies of water (permanent or temporary) in order to breed. Frogs with their permeable skins can easily absorb toxins and as such can also serve as a valuable bio-indicator as to the overall health of a water system. In addition, tadpoles serve an important function as they feed on algae that occurs in the freshwater body, keep algal levels in check. Frogs, like many smaller species also form an important food resource in the food chain, being predated upon by several other predatory species from mammals, reptiles and avifauna.

Although frogs in the Northern Cape are not as common and abundant as in areas of higher rainfall, there are still several species that are capable of surviving in the more arid environments. The South African Frog Atlas (SAFAP) indicates two species that have previously been recorded in the habitat surrounding the mining area, namely *Bufo poweri* (Power's Toad) and *Breviceps adspersus* (Bushveld Rain Frog). Both these species are able to survive away from water; however, they would likely utilise the pit lake for breeding purposes.

Invertebrates

Insect species form the backbone of any ecosystem, as they not only serve as an important food resource for many other faunal species, but are also pollinators and herbivores, removing a significant amount of herbaceous material. Monitoring of the insect species diversity and abundance provides a good indicator of the overall health of the ecosystem, whilst also providing additional information as to why other faunal species may be declining form an areas.

Arachnid species are adept at surviving in arid environments, notably in the northern cape, however their small size often limits their dispersal rate. A such, arachnid diversity and abundance is likely to lag behind other species in terms of recolonising the pit lake and rehabilitated areas. However, monitoring activities for such species should be undertaken in order to ascertain their rate of recolonization, which will provide valuable information as to the overall success of the pit lake rehabilitation activities.

Reptiles

Reptile species are an integral part of the more arid environments, are fairly adaptable and appear to have the ability to exist in areas where habitat degradation has occurred, provided that there are sufficient food resources and areas of refuge for them. Although reptile species might not directly utilise the pit lake itself, they will readily utilise the surrounding revegetated areas. In this regard, it is important that the in the surrounding revegetated areas suitable micro habitat structures for reptiles are created. These micro-habitats includes areas of exposed rock piles as well as dead trees trunks placed on the ground. Reptiles will likely be some of the first species to start recolonising the rehabilitated areas, with other species following them. Reptile species diversity will likely increase as prey species abundance and diversity increases (insects and small mammals).

It is important that the pit lake designs accommodate for the less mobile reptile species, notably tortoise species, as they will from on a periodic basis use the pit lake to rehydrate, notably during extended dry spells and when they are unable to attain the necessary moisture requirements from the vegetation. As such bank design needs to take such access constraints into consideration to ensure accessibility for these species.

Figure 16: Illustrative image of *Stigmochelys pardalis* (Leopard Tortoise) in the shallow waters along the bank of a lake.

8. FRESHWATER MONITORING PLAN

Monitoring is essential in order to scientifically prove that a self-sustainable aquatic ecosystem has developed or show a positive trend towards successful rehabilitation. This will prove that environmental degradation and biological diversity have been mitigated and restored where it has been negatively impacted upon. The important aspect to keep in mind is that it is not only a visual inspection, but measurable information gathering e.g. water quality (both ground and surface), aquatic vegetation, eutrophic levels and aquatic macro-invertebrate diversity etc. The monitoring data must be of such a standard that meaningful conclusions can be made and a trend indicated. Good record keeping is essential in order to provide long term analysis of the collected data as well as ecological trends.

The following points aim to guide the design of the monitoring plan, and it must be noted that the monitoring plan must be continually updated and refined for site-specific requirements:

Surface and Groundwater Quality Compliance with Agreed Conditions:

Surface Water Quality: Surface water sampling must be undertaken regularly, and if water quality is found to contain constituents of concern exceeding the agreed objectives, then measures to treat the water should be investigated. Water quality monitoring must include analyses of the following parameters:

- Basic chemistry:
  - pH;
  - EC;
  - DO;
  - Nitrate;
  - Phosphate;
  - Sulphate; and
  - Temperature.
- ICP elemental scan with specific mention of:
  - F;
  - Pb;
  - Hg;
  - Se;
  - Cu; and
  - Zn;
- COD; and
- BOD

The results should be compared temporarily to determine whether the trajectory of change is acceptable in terms of supporting aquatic life.

Whole Effluent Toxicity (WET) Testing:

In order to qualify and quantify the ability of water in the pit lake to support aquatic life and to assess possible acute effects on aquatic organisms, acute WET tests must be performed. The battery of WET tests must include *Daphnia pulex* (representing aquatic macro-invertebrates), *Poecilia reticulata* (representing fish fauna) *Vibrio fischeri* (representing bacteria) and *Selenastrum capricornutum* (representing algae/aquatic macrophytes). The *Selenastrum capricornutum* can also determine the risk of eutrophication of the system. WET testing should be conducted on a six monthly basis and results compared temporally.

Eutrophication Testing:

If a risk of eutrophication is becoming evident, based on physic-chemcial data analyses and the results of the *Selenastrum capricornutum* test, further analyses to define the risk of eutrophication should be undertaken by means of determination of Chlorophyll a concentration and algal species identification

Habitat and Aquatic Macro-Invertebrate Assessment:

An analyses of the aquatic macro-invertebrate community diversity, sensitivity and abundance should take place at an interval of every two years. In addition to the aquatic macro-invertebrate community assessment, a visual assessment of habitat conditions should be undertaken. The results should be compared temporarily to determine whether the trajectory of change is acceptable in terms of the desired outcomes.

9. BIODIVERSITY MONITORING PLAN

Monitoring is essential in order to scientifically prove that a self-sustainable ecosystem has developed or show a positive trend towards successful rehabilitation. This will prove that environmental degradation and biological diversity have been mitigated and restored, where it has been negatively impacted upon. The important aspect to keep in mind is that it is not only a visual inspection but measurable information gathering, e.g. soil samples, vegetation diversity, basal cover, species composition etc. The monitoring data must be of such a standard that meaningful conclusions can be made and a trend indicated. Good record keeping is essential in order to provide long term analysis of the collected data as well as ecological trends.

In order to accurately monitor the effectiveness of revelation activities, it is important to implement a floral monitoring plan. The following points aim to guide the design of the monitoring plan, and it must be noted that the monitoring plan must be continually updated and refined for site-specific requirements:

- Permanent floral monitoring plots must be established in the rehabilitated areas. These plots must be designed to accurately monitor the following parameters:
  - Measurements of the crown and basal cover;
  - Species diversity;
  - Species abundance;
  - Recruitment of indigenous species;
  - Alien vs Indigenous plant ratio;
  - Recruitment of alien and invasive plant species;
  - Effectiveness of alien and invasive plant control measures;
  - Erosion levels and the efficacy of erosion control measures; and
  - Vegetation community structure including species composition and diversity which should be compared to the previous round of monitoring.
- Monitoring must take place on an annually basis until it is deemed that natural ecological systems and functions have started to take over and that the pit lake has become a self-functioning and regulating ecosystem;
- The rehabilitation plans must be continuously updated in accordance with the monitoring results in order to ensure that optimal rehabilitation measures are employed; and
- The method of monitoring must be designed to be subjective and repeatable in order to ensure consistent results.

In order to assess the effectiveness of the rehabilitation plans as well as the pitlake it is important that faunal species diversity, abundance and habitat use is assessed. Faunal monitoring will provide valuable insight into the effectiveness of the habitat creation and development, whilst also indicating the rate at which faunal species are recolonising the rehabilitated area. Monitoring will also indicate if the lake is serving its proposed purpose of providing aquatic habitats and breeding zones for faunal species, whilst also forming a useable water resource in the area.

The following points aim to guide the design of the monitoring plan. It must be noted that the monitoring plan must be continually updated and refined for site-specific requirements:

- Permanent monitoring points must be established in areas within the rehabilitated site in various habitat areas and degrees of topography i.e. banks/riparian zone of the pitlake, grassland areas and if applicable areas of increased woody vegetation. These points must be designed to accurately monitor the following parameters:
  - Species diversity (mammal, invertebrate, amphibian, reptile and avifaunal);
  - Species abundance; and
  - Faunal community structure including species composition and diversity, which can be compared to year on year results in order to assess trends;
- The following methods aim to guide the monitoring plan, although more detailed, site-specific methods must be employed during the development and implementation of the monitoring plan:
  - Monitoring activities must take place on an annual basis as a minimum, but on a bi-annual basis ideally, one winter and one summer monitoring session;
  - Annual walk down of all banks along the pit lake, as the pit lake will be used as a water resource and many species will move along the edges of the lake. All spoor, scat and signs of faunal species occurrence must be identified and recorded;
  - Sherman trapping should be done on an annual basis to monitor small mammal diversity;
  - Camera trap surveys should be conducted on a bi-annual basis, a winter and a summer trapping survey, for medium to large mammals, as well as cryptic and nocturnal species;
- The following criteria must be used with regards to the avifaunal monitoring:
  - Fixed and random points for bird counts to determine species composition and diversity trends. At these points, the observer must record all avifaunal species and total of species observed at the point. A Bird Laser app that can be downloaded onto a smartphone can assist with record keeping, all necessary information can be captured;
  - Proposed avifaunal fixed-point monitoring must be monitored bi-annually (July and February) in order to record summer as well as winter avifaunal species utilising the focus area; and
- The method of monitoring must be designed to be subjective and repeatable in order to ensure consistent results.

10. IMPACT ASSESSMENT

10.1 Impacts Assessment Methodology

The method to be used for assessing risks/impacts is outlined in the sections below. The first stage of risk/impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are presented below.

- An **activity** is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructure that are possessed by an organisation.
- An **environmental aspect** is an 'element of an organizations activities, products and services which can interact with the environment'[1]. The interaction of an aspect with the environment may result in an impact.
- **Environmental benefits/impacts** are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise and health effects due to poorer air quality. In the case where the impact is on human health or well-being, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.
- **Receptors** can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as wetlands, flora and riverine systems.
- **Resources** include components of the biophysical environment.
- **Frequency of activity** refers to how often the proposed activity will take place.
- **Frequency of impact** refers to the frequency with which a stressor (aspect) will impact on the receptor.
- **Severity** refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
- **Spatial extent** refers to the geographical scale of the impact.
- **Duration** refers to the length of time over which the stressor will cause a change in the resource or receptor.

[1] The definition has been aligned with that used in the ISO 14001 Standard.

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria. Refer to the table below. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance rating matrix and are used to determine whether mitigation is necessary[2].

The assessment of significance is undertaken twice. Initial, significance is based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts. Measures such as demolishing infrastructure, and reinstatement and rehabilitation of land, are considered post-mitigation.

The model outcome of the impacts was then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in line with South Africa's National Environmental Management Act (No. 108 of 1997) in instances of uncertainty or lack of information, by increasing assigned ratings or adjusting final model outcomes. In certain instances where a variable or outcome requires rational adjustment due to model limitations, the model outcomes have been adjusted.

Table 14: Criteria for assessing significance of impacts

LIKELIHOOD DESCRIPTORS

Probability of impact or benefit	**RATING**
Highly unlikely	1
Possible	2
Likely	3
Highly likely	4
Definite	5
Ecological impact or benefit that can be derived	**RATING**
Ecology not sensitive/important	1
Ecology with limited sensitivity/importance	2
Ecology moderately sensitive/ /important	3
Ecology highly sensitive /important	4
Ecology critically sensitive /important	5

CONSEQUENCE DESCRIPTORS

Severity/Magnitude of impact or benefit	**RATING**
Insignificant / ecosystem structure and function unchanged	1
Small / ecosystem structure and function largely unchanged	2

[2] Some risks/impacts that have low significance will however still require mitigation

Significant / ecosystem structure and function moderately altered	3
Great / harmful/ ecosystem structure and function largely altered	4
Disastrous / ecosystem structure and function very significantly altered	5
Spatial scope of impact or benefit	**RATING**
Activity specific/ < 5 ha impacted / Linear features affected < 100m	1
Development specific/ within the site boundary / < 100ha impacted / Linear features affected <	2
Local area/ within 1 km of the site boundary / < 2000ha impacted / Linear features affected <	3
Regional within 5 km of the site boundary / < 5000ha impacted / Linear features affected < 10	4
Entire habitat unit / Entire system/ > 5000ha impacted / Linear features affected > 10 000m	5
Duration of impact or benefit	**RATING**
One day to one month	1
One month to one year	2
One year to five years	3
Life of operation or less than 20 years	4
Permanent	5

Table 15: Significance rating matrix

	CONSEQUENCE (Severity + Spatial Scope + Duration)														
LIKELIHOOD (Frequency of activity + Frequency of impact)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 16: Positive/Negative Mitigation Ratings

Significance Rating	Value	Negative Impact management recommendation	Positive Impact management recommendation
Very High	126 - 150	Consider the viability of the project. Very strict measures to be implemented to mitigate impacts according to the impact mitigation hierarchy	Actively promote the project
High	101 - 125	Consider alternatives in terms of project execution and location. Ensure designs take environmental sensitivities into account and Ensure management and housekeeping is maintained and attention to impact minimisation is paid according to the impact mitigation hierarchy	Promote the project and monitor ecological performance
Medium High	76 – 100	Consider alternatives in terms of project execution and Ensure management and housekeeping is maintained and attention to impact minimisation is paid according to the impact mitigation hierarchy	Implement measures to enhance the ecologically positive aspects of the project while managing any negative impacts
Medium Low	51 - 75	Ensure management and housekeeping is maintained and attention to impact minimisation is paid	Implement measures to enhance the ecologically positive aspects of the project while actively managing any negative impacts
Low	26 - 50	Promote the project and ensure management and housekeeping is maintained	Monitor ecological performance and pay extensive attention to minimising potential negative environmental impacts
Low Very	1 - 25	Promote the project	Actively seek measures to implement impact minimisation according to the impact mitigation hierarchy and identify positive ecological aspects to be promoted

The following points were considered when undertaking the assessment:

- Benefits and impacts were analysed in the context of the *project's area of influence* encompassing:
  - Primary project site and related facilities that the client and its contractors develop or control;
  - Areas potentially impacted by cumulative impacts for further planned development of the project, any existing project or condition and other project-related developments; and
  - Areas potentially affected by impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.
- Benefits/Impacts were assessed for all stages of the project cycle including:
  - Closure and rehabilitation;
  - Pit filling/flooding; and
  - Post closure/residual impacts.
- If applicable, transboundary or global effects were assessed;
- Individuals or groups who may be differentially or disproportionately affected by the project because of their *disadvantaged* or *vulnerable* status were assessed.

- Particular attention was paid to describing any residual impacts that will occur after rehabilitation.

10.2 Mitigation Measure Development

The following points present the key concepts considered in the development of mitigation measures for the proposed development.

- *Mitigation* and *performance improvement measures* and actions that address the risks and impacts[3] are identified and described in as much detail as possible.
- Measures and actions to address negative impacts will favour avoidance and prevention over minimisation, mitigation or compensation.
- Desired outcomes are defined and have been developed in such a way as to be *measurable events with performance indicators, targets and acceptable criteria* that can be tracked over *defined periods*, with estimates of the *resources* (including human resource and training requirements) *and responsibilities for implementation*.

10.3 Aquatic Ecological Impacts

IMPACT 1: CREATION OF AQUATIC HABITAT

Globally modification of habitats for agriculture is the chief cause of such habitat loss. Habitat destruction is presently ranked as the most significant cause of species population decrease and ultimately species extinction worldwide.

Habitat creation or enhancement is the alteration of an impacted area or habitat to the point that it is rendered fit to support species dependent upon a specific set of conditions leading to an area that can be defined as their home territory. Habitat creation or enhancement may cause an increase in biodiversity complexity, diversity, community sensitivity and overall community stability, due to organisms which were previously utilising the area which were displaced or destroyed being re-introduced to an area.

The proposed concurrent backfill and in pit dumping program which will result in the formation of an EPL has the potential to create a new source of surface water habitat in the area which can provide habitat for aquatic and semi aquatic species and thereby contribute to the biodiversity and ecological richness of the area, albeit in an artificial manner. It is however deemed essential that the backfilling and landscaping of the pit be done with strict

[3] Mitigation measures should address both positive and negative impacts

consideration of aquatic ecological principles as defined in the ecological design criteria presented in section 7.1 of this report.

It is clear from the above discussion that the impact on the area from an aquatic ecological point of view will be positive. The impact assessment below aims to define the significance of the positive impact in the various phases of the project.

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Backfilling and rehabilitation	1	1	1	1	3	2	5	10
Pit filling/flooding	2	1	2	1	4	3	7	21
Post closure/aftercare and maintenance	3	2	3	1	5	5	9	45
With Management								
Backfilling and rehabilitation	2	1	2	1	3	3	6	18
Pit filling/flooding	3	2	3	1	4	5	8	40
Post closure/aftercare and maintenance	4	3	4	4	5	7	13	91

Based on the application of the impact assessment, it can be concluded that without mitigation, although no negative aquatic ecological impacts are expected, the significance of the positive impact is low. Furthermore, during the backfilling and rehabilitation phases and during the first filling of the pit, which is expected to take several decades, the significance of the positive impact, from a habitat provision point of view is very low.

With mitigation and through strict adherence to the ecological design criteria presented in this study throughout the design, backfilling, rehabilitation and aftercare and maintenance phase the significance of the positive impact is increased to moderately low during first filling and moderately high during the post closure/aftercare and maintenance period.

IMPACT 2: INCREASE IN AQUATIC BIODIVERSITY AND AQUATIC COMMUNITY PREVALENCE AND STABILITY

Loss or a decrease of aquatic biodiversity and sensitive taxa is largely driven by stressors such as altered or impaired water quality and habitat loss or unavailability. Based on the findings of the pit water quality monitoring, the water quality in the pit is expected to be relatively good for the foreseeable future and thus have the potential to support an aquatic community of reasonable diversity and sensitivity. In turn the functional aquatic habitat can then assist in cycling and assimilating nutrients and thus assist in improving or maintaining water quality.

The proposed concurrent backfill and in pit dumping program which will result in the formation of an EPL has the potential to create a new source of surface water habitat in the area which can provide habitat for aquatic and semi aquatic species and thereby contribute to the biodiversity and ecological richness of the area, albeit in an artificial manner. It is however deemed essential that the backfilling and landscaping of the pit be done with strict consideration of aquatic ecological principles as defined in the ecological design criteria presented in section 7.1 of this report. Furthermore, it is deemed essential that biological interventions such as the development of floating wetlands and the introduction of indigenous fish species take place to speed up the process of food web generation and stabilisation.

It is clear from the above discussion that the impact on the area from an aquatic ecological point of view will be positive, albeit artificial. The impact assessment below aims to define the significance of the positive impact in the various phases of the project.

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Backfilling and rehabilitation	1	1	1	1	3	2	5	10
Pit filling/flooding	2	1	2	1	4	3	7	21
Post closure/aftercare and maintenance	3	2	3	1	5	5	9	45
With Management								
Backfilling and rehabilitation	2	1	2	1	3	3	6	18
Pit filling/flooding	3	2	3	1	4	5	8	40
Post closure/aftercare and maintenance	4	3	4	4	5	7	13	91

Based on the application of the impact assessment, it can be concluded that without mitigation, although no negative aquatic ecological impacts are expected, the significance of the positive impact is low. Furthermore, during the backfilling and rehabilitation phases and during the first filling of the pit, which is expected to take several decades, the significance of the positive impact, from an aquatic biodiversity point of view is very low.

With mitigation and through strict adherence to the ecological design criteria presented in this study throughout the design, backfilling, rehabilitation and aftercare and maintenance phase the significance of the positive impact is increased to moderately low during first filling and moderately high during the post closure/aftercare and maintenance period.

10.4 Terrestrial Ecological Impacts

IMPACT 1: CREATION OF TERRESTRIAL HABITAT THROUGH AREA REHABILITATION

The advent of technological advances and human population growth has led to a substantial loss of biodiversity on a global scale, which shows no signs of slowing down. Ever expanding human populations require more and more natural resources and food supplies, leading to the further expansion of agricultural areas as well as mines.

Habitat creation or enhancement is the alteration of an impacted area or habitat to the point that it is rendered fit to support species dependent upon a specific set of conditions leading to an area that can be defined as their home territory. Habitat creation or enhancement may cause an increase in biodiversity complexity, diversity, community sensitivity and overall community stability, due to organisms which were previously utilising the area which were displaced or destroyed being re-introduced to an area.

The proposed concurrent backfill and in pit dumping program will result in the formation of a pit lake in conjunction with the rehabilitation of the surrounding mining area has the potential to create a new source of habitat and a source of surface water. The proposed pit lake and revegetated areas have the potential to provide habitat to numerous species, leading to a possible increase in the biodiversity and ecological richness of the area, albeit in an artificial manner. It is however deemed essential that the backfilling and landscaping of the pit be done with strict consideration of terrestrial ecological requirements and principles as defined in the ecological design criteria presented in section 7.2 of this report.

Provided that all measures as discussed in Section 7.2 along with a well-designed rehabilitation and monitoring plan are implemented, it is likely that the impacts associated with the proposed pit lake will be positive. The impact assessment below aims to define the significance of the positive impact in the various phases of the project.

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Backfilling and rehabilitation	3	1	1	2	3	4	6	-24
Pit filling/flooding	4	2	3	3	4	6	10	-60
Post closure/aftercare and maintenance	5	3	4	4	5	8	13	-104
With Management								
Backfilling and rehabilitation	2	1	2	2	3	3	7	21
Pit filling/flooding	3	2	4	3	4	5	11	55
Post closure/aftercare and maintenance	4	3	4	4	5	7	13	91

Based on the above impact assessment, it can be concluded that without mitigation there will be very limited positive impacts to the receiving environment. Without mitigation the negative impacts are likely to be significantly higher due to the lack of terrestrial habitat development and the proliferation of alien and invasive plant species, which will likely spread to the neighbouring natural habitat leading to further habitat disturbance and alteration. Without mitigation the first filling and post closure phases are likely to have a moderately low to high negative impact to the receiving environment

With mitigation and through strict adherence to the ecological design criteria presented in this study throughout the design, backfilling, rehabilitation and aftercare and maintenance phase the significance of the positive impact may increase to moderately low during first filling and moderately high during the post closure/aftercare and maintenance period due to the creation of terrestrial habitat through revegetation activities. During the period in which it takes the pit to fill, concentrated effort can be placed on ensuring that all revegetation activities are progressing as planned and that habitat re-establishment is occurring.

IMPACT 2: INCREASE IN TERRESTRIAL BIODIVERSITY AND ABUNDANCE

The advent of mining has led to the loss of faunal and floral diversity and abundance throughout South Africa. In particular, the construction and operation of the Tshipi Borwa Mine has led to localised loss of species diversity and abundance. The revegetation and reseeding activities will result in an increase in floral abundance and diversity, which if managed suitable, will increase over time in species richness. The advent of increased floral species abundance and diversity will lead to the recolonisation of faunal species, which will promote ecosystem development and complexity. Provided that rehabilitation activities continue and are suitably monitored and managed, the rehabilitated areas will progress through the various stages of ecological succession, leading to stable ecological state similar to that of pre-mining conditions.

In order to achieve an increased species diversity and abundance, it is important that the backfilling and landscaping of the pit be undertaken with consideration of the terrestrial ecological principles as defined in the ecological design criteria presented in section 7.2 of this report. Furthermore, it is deemed essential that the all alien and invasive plant species are controlled and removed, as the proliferation of these will lead to a loss of floral diversity and concurrently faunal diversity, leading to a loss of species diversity and failure of the rehabilitation efforts.

That the impact on the area from a terrestrial ecological point of view is expected to be positive, provided that all control and management measures are adhered to. The impact assessment below aims to define the significance of the positive impact in the various phases of the project.

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Backfilling and rehabilitation	2	1	1	2	3	3	6	-18
Pit filling/flooding	4	2	3	3	4	6	10	-60
Post closure/aftercare and maintenance	5	3	4	4	5	8	13	-104
With Management								
Backfilling and rehabilitation	2	1	2	2	3	3	7	21
Pit filling/flooding	3	3	4	3	4	6	11	66
Post closure/aftercare and maintenance	4	3	4	4	5	7	13	91

Based on the above impact assessment, it can be concluded that without mitigation there will be very limited positive impacts to faunal species diversity and abundance, with an unacceptable levels of biodiversity re-instatement. Without mitigation the negative impacts are likely to be significantly higher leading to the long term loss of species diversity and proliferation of alien and invasive plant species. Without mitigation the first filling and post closure phases are likely to have a moderately low to high negative impact to the receiving environment.

With mitigation and through strict adherence to the ecological design criteria presented in this study throughout the design, backfilling, rehabilitation and aftercare and maintenance phase the significance of the positive impact may increase to moderately low during first filling and moderately high during the post closure/aftercare and maintenance period due to the creation of terrestrial habitat through revegetation activities. During the period in which it takes the pit to fill, concentrated effort can be placed on ensuring that all revegetation activities are progressing as planned and that species diversity and abundance is increasing through consistent monitoring of the fauna and flora.

IMPACT 3: POTENTIAL FOR CREATION OF A NICHE FRESHWATER HABITAT

The advent of creating a freshwater resource in an otherwise arid environment poses significant niche potential, for all forms of faunal and floral species. The creation of such habitat will lead to an increase in species populations that were otherwise limited as a result of the lack of stable freshwater water habitats, notably aquatic plants, amphibians, waterfowl and several insect species. Not only does the pit lake have the potential to create niche habitat, but also serve as an important source of water for faunal species in the region.

Based on the findings of the pit water quality monitoring, the water quality in the pit is expected to be relatively good for the foreseeable future, however there is a concern surrounding mercury, nitrates and TDS that appear to spike to unsafe levels after 100 years. If these concerns can be managed and mitigated then it is likely that the development of the pit lake will be a positive for faunal and floral species, and the overall ecology of the area.

The creation of a niche freshwater habitat in the area can be regarded as positive, notably due to the overall arid environment and limited sources of permanent useable surface water in region. The positive impact has been assessed below.

Without Management	Probability of Impact	Sensitivity of receiving environment	Severity	Spatial scale	Duration of impact	Likelihood	Consequence	Significance
Backfilling and rehabilitation	2	1	1	2	3	3	6	-18
Pit filling/flooding	4	2	3	3	4	6	10	-60
Post closure/aftercare and maintenance	4	3	3	4	5	7	12	-84
With Management								
Backfilling and rehabilitation	2	1	2	2	3	3	7	21
Pit filling/flooding	3	2	3	3	4	6	10	60
Post closure/aftercare and maintenance	4	3	4	4	5	7	13	91

Based on the above impact assessment, it can be concluded that without mitigation the impacts will only be negative as no niche habitat will be created nor will the overall habitat be viable for terrestrial species that are freshwater dependant. Without mitigation the negative impacts are likely to lead to the continued and long term loss of species diversity in the region. The first filling and post closure phases are likely to have a moderately low to medium high negative impact to the receiving environment without mitigation measures implemented.

With mitigation and through strict adherence to the ecological design criteria presented in this study throughout the design, backfilling, rehabilitation and aftercare and maintenance phase the significance of the positive impact may increase to moderately low during first filling and moderately high during the post closure/aftercare and maintenance period as revegetation activities and the creation of niche freshwater habitats come into effect. It must be ensured that bankside vegetation is stable and that where applicable the floating wetlands as discussed in section 7.2 are functioning. The bankside vegetation and floating wetlands will serve as significant niche habitats for faunal species whilst of all classes whilst also providing valuable areas of refuge and food resources.

10.5 SYNTHESIS

In conclusion the creation of an end pit lake has the potential to provide a unique opportunity to increase aquatic biodiversity in the area, albeit in an artificial way. The creation of the EPL will also lead to the creation of a niche freshwater related habitats (bank vegetation and floating wetlands) for faunal and floral species, whilst also serving as an important water resource for fauna in the region. The rehabilitation of the surrounding mining area through topography landscaping and revegetation will further create habitat for fauna and flora, leading to an increased biodiversity richness of the area. Provided that this initiative is appropriately designed, managed and implemented it could lead to medium high significance benefits for both the aquatic and terrestrial environments.

11. REFERENCES

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APPENDIX A: PROJECT TEAM CVS

1. (a) (i) Details of the specialist who prepared the report

Stephen van Staden MSc (Environmental Management) (University of Johannesburg)

1. (a). (ii) The expertise of that specialist to compile a specialist report including a curriculum vitae

Company of Specialist:	Scientific Aquatic Services		
Name / Contact person:	Stephen van Staden		
Postal address:	29 Arterial Road West, Oriel, Bedfordview		
Postal code:	2007	Cell:	083 415 2356
Telephone:	011 616 7893	Fax:	011 615 6240/ 086 724 3132
E-mail:	stephen@sasenvgroup.co.za		
Qualifications	MSc (Environmental Management) (University of Johannesburg) BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg) BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)		
Registration / Associations	Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP) Accredited River Health practitioner by the South African River Health Program (RHP) Member of the South African Soil Surveyors Association (SASSO) Member of the Gauteng Wetland Forum		

1. (b) A declaration that the specialist is independent in a form as may be specified by the competent authority

I, Stephen van Staden, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct

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Signature of the Project Manager

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF CHRISTOPHER HOOTON

PERSONAL DETAILS

Position in Company	Ecologist
Date of Birth	24 June 1986
Nationality	South African
Languages	English, Afrikaans
Joined SAS	2013

EDUCATION

Qualifications

BTech Nature Conservation (Tshwane University of Technology)	2013
National Diploma Nature Conservation (Tshwane University of Technology)	2008

COUNTRIES OF WORK EXPERIENCE

South Africa – Gauteng, Mpumalanga, North West, Limpopo, KwaZulu-Natal, Eastern Cape, Western Cape, Northern Cape, Free State

Zimbabwe, Sierra Leone

SELECTED PROJECT EXAMPLES

Faunal Assessments

- Faunal assessment as part of the environmental assessment and authorisation process for the expansion activities at Der Brochen Platinum Mine, Limpopo;
- Faunal and floral assessment as part of the environmental assessment and authorisation process for the upgrading of roads at the Modikwa Platinum Mine, Limpopo;
- Faunal and floral assessment update as part of the environmental assessment and authorisation process for the expansion activities at Twickenham Platinum Mine, Limpopo;
- Faunal assessment as part of the environmental assessment and authorisation process for the proposed The Duel Coal Mine, Limpopo;
- Faunal assessment as part of the environmental assessment and authorisation process for the proposed reopening of historical mine shafts at Sabie and Pilgrims Rest by TGME, Mpumalanga;
- Wilderness Risk Assessment as part of the environmental assessment and authorisation process for the proposed Fuleni Coal Mine, KwaZulu Natal;
- Faunal and floral assessment as part of the environmental assessment and authorisation process for the proposed Rietkol Mine, Mpumalanga;
- Faunal assessment as part of the environmental assessment and authorisation process for the proposed expansion of mining activities at Sierra Rutile Mine, Sierra Leon;
- Faunal and floral assessment as part of the environmental assessment and authorisation process for the proposed Heuningkranz Mine, Northern Cape;
- Faunal assessment as part of the environmental assessment and authorisation process for the proposed Mzimvubu Water Project, Eastern Cape.

- Faunal assessment as part of the environmental assessment and authorisation process for the development of a proposed abalone farm, Brand se Baai, Western Cape.
- Faunal assessment as part of the environmental assessment and authorisation process for the development of a proposed abalone farm, Doringbaai, Western Cape.
- Vegetation composition and subsequent loss of carrying capacity for the Rand Water B19 and VG Residue Pipeline Project, Freestate.
- Faunal assessment as part of the environmental assessment and authorisation process for the Evander Shaft 6 Plant Upgrade, New Tailings Dam Area and Associated Tailings Delivery and Return Water Pipeline, Evander, Mpumalanga.

Previous Work Experience

- Spotted Hyaena Research Project, Phinda Private Game Reserve, KwaZulu Natal.
- Camera Trap Survey as part of the Munyawana Leopard Project, Mkuze Game Reserve, KwaZulu Natal.
- Lowveld Wild Dog Project, Savé Valley Conservancy, Zimbabwe.
- Lion collaring and Tracking as part lion management program, Savé Valley Conservancy, Zimbabwe.
- Junior Nature Conservator, Gauteng Department of Rural Development and Land Reform.

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF KIM DALHUIJSEN

PERSONAL DETAILS

Position in Company	Consultant
Date of Birth	28 February 1989
Nationality	The Netherlands
Languages	English, Afrikaans
Joined SAS	2015 - Present

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered member of the South African Affiliation of the International Association of Impact Assessment (IAIAsa)

EDUCATION

Qualifications

Certificate in Environmental Law for Environmental Managers (CEM)	2014
Certificate for Introduction to Environmental Management (CEM)	2013
BSc (Hons) Zoology (Herpetology) (University of the Witwatersrand)	2012
BSc (Zoology and Environment, Ecology and Conservation) (University of Witwatersrand)	2011

COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces

West Africa – Uganda

PREVIOUS EMPLOYMENT

Position	Junior Environmental Scientist
Company	ILISO Consulting (Pty) Ltd
Employment	2013 - 2015

SELECTED PROJECT EXAMPLES

Wetland delineation and wetland function assessment

- Wetland Assessment for the sewage Bulk Service System for the Val de Vie development, Paarl, Western Cape.
- Wetland Assessment for the Riverfarm Development for the Val de Vie development, Paarl, Western Cape
- Wetland Assessment for the development of three agricultural dams for irrigation of crops, Cape Farms, Western Cape.
- Wetland Assessment for the Willow Wood Estate Sewage pipeline upgrade, D'Urbanvale, Western Cape
- Wetland Assessment for the rectification of infilling of a freshwater feature, D'Urbanvale, Western Cape.

- Freshwater Assessment for the stabilisation of the Franschhoek River embankment, Leeu Estates, Franschhoek, Western Cape.

Water Use Authorisations

- WUA for the SANRAL N3 De Beers Pass Section within the Free State and KwaZulu-Natal.
- Assistance with the WULA for the Mzimvubu Water Project, Eastern Cape.
- WUA for the Excelsior Wind Energy Farm and associated powerline infrastructure, Swellendam, Western Cape.
- WUA for the Golden Valley Phase II Wind Energy Facility, Eastern Cape.
- WUA for the sewage Bulk Service system for the Val de Vie Polo and Lifestyle Estate, Paarl, Western Cape.
- WUA for the Riverfarm Development for the Val de Vie Polo and Lifestyle Estate, Paarl, Western Cape.
- WUA for the Pearl Valley II development for the Val de Vie Polo and Lifestyle Estate, Paarl, Western Cape.
- WUA for the Levendal Village for the Val de Vie Polo and Lifestyle Estate, Paarl, Western Cape.
- WUA for a residential development, Klapmuts, Western Cape.

Public Participation and Environmental Impact Assessments

- Public Participation for the Environmental Impact Assessment for the Eskom Photovoltaic Plant at Arnot and Duvha Power Station.
- Eskom Hendrina to Gumeni sub-stations 400 kV Powerline. Co-ordination of Heritage and Ecological Assessment and updating the Construction and Operation Environmental Management Plan.
- Public Participation Team Leader for the Mzimvubu Dam Environmental Impact Assessment.
- Public Participation Process for Eskom Exemption from and Postponement of Air Emission Licence Applications.
- EIA for Eskom Vierfontien to Wawielpark 22 kV Transmission line refurbishing.
- Junior Environmental Scientist for the Hartbeespoort Waste Charge Discharge System.
- Public Participation Process for City of Tshwane's Bus Rapid Transit from Pretoria Station to Rainbow Junction.
- EIA for the Rwengaaju Model Village Irrigation Scheme in Kabarole District, Uganda.
- EIA for tte Water supply and Sanitation system in Moroto, Bugaddem Kacheri-Lokona, Nakapelimoru and Kotido, Uganda.
- EIA for the Farm Income Enhancement and Forestry Conservation Project: Irrigation Scheme for Katete, Kibimba and Mubuku II, Uganda.

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF STEPHEN VAN STADEN

PERSONAL DETAILS

Position in Company	Managing member, Ecologist, Aquatic Ecologist
Date of Birth	13 July 1979
Nationality	South African
Languages	English, Afrikaans
Joined SAS	2003 (year of establishment)

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)
Accredited River Health practitioner by the South African River Health Program (RHP)
Member of the South African Soil Surveyors Association (SASSO)
Member of the Gauteng Wetland Forum

EDUCATION

Qualifications

MSc (Environmental Management) (University of Johannesburg)	2002
BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg)	2000
BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)	1999

COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces
Southern Africa – Lesotho, Botswana, Mozambique, Zimbabwe
Eastern Africa – Tanzania
West Africa – Ghana, Liberia, Angola, Guinea Bissau
Central Africa – Democratic Republic of the Congo

SELECTED PROJECT EXAMPLES

Development compliance studies

- Project co-leader for the development of the EMP for the use of the Wanderers stadium for the Ubuntu village for the World Summit on Sustainable Development (WSSD).
- Environmental Control Officer for Eskom for the construction of an 86Km 400KV power line in the Rustenburg Region.
- Numerous Environmental Impact Assessment (EIA) and EIA exemption applications for township developments and as part of the Development Facilitation Act requirements.
- EIA for the extension of mining rights for a Platinum mine in the Rustenburg area by Lonmin Platinum.
- EIA Exemption application for a proposed biodiesel refinery in Chamdor.
- Compilation of an EIA as part of the Bankable Feasibility Study process for proposed mining of a gold deposit in the Lofa province, Liberia.
- EIA for the development of a Chrome Recovery Plant at the Two Rivers Platinum Mine in the Limpopo province, South Africa.
- Compilation of an EIA as part of the Bankable Feasibility Study process for the Mooihoek Chrome Mine in the Limpopo province, South Africa.
- Mine Closure Plan for the Vlakfontein Nickel Mine in the North West Province.

Specialist studies and project management

- Development of a zero discharge strategy and associated risk, gap and cost benefit analyses for the Lonmin Platinum group.
- Development of a computerised water balance monitoring and management tool for the management of Lonmin Platinum process and purchased water.
- The compilation of the annual water monitoring and management program for the Lonmin Platinum group of mines.

- Analyses of ground water for potable use on a small diamond mine in the North West Province.
- Project management and overview of various soil and land capability studies for residential, industrial and mining developments.
- The design of a stream diversion of a tributary of the Olifants River for a proposed opencast coal mine.
- Waste rock dump design for a gold mine in the North West province.
- Numerous wetland delineation and function studies in the North West, Gauteng and Mpumalanga Kwa-Zulu Natal provinces, South Africa.
- Hartebeespoort Dam Littoral and Shoreline PES and rehabilitation plan.
- Development of rehabilitation principles and guidelines for the Crocodile West Marico Catchment, DWAF North West.

Aquatic and water quality monitoring and compliance reporting

- Development of the Resource Quality Objective framework for Water Use licensing in the Crocodile West Marico Water Management Area.
- Development of the Resource Quality Objectives for the Local Authorities in the Upper Crocodile West Marico Water Management Area.
- Development of the 2010 State of the Rivers Report for the City of Johannesburg.
- Development of an annual report detailing the results of the Lonmin Platinum groups water monitoring program.
- Development of an annual report detailing the results of the Everest Platinum Mine water monitoring program.
- Initiation and management of a physical, chemical and biological monitoring program, President Steyn Gold Mine Welkom.
- Aquatic biomonitoring programs for several Xstrata Alloys Mines and Smelters.
- Aquatic biomonitoring programs for several Anglo Platinum Mines.
- Aquatic biomonitoring programs for African Rainbow Minerals Mines.
- Aquatic biomonitoring programs for several Assmang Chrome Operations.
- Aquatic biomonitoring programs for Petra Diamonds.
- Aquatic biomonitoring programs for several coal mining operations.
- Aquatic biomonitoring programs for several Gold mining operations.
- Aquatic biomonitoring programs for several mining operations for various minerals including iron ore, and small platinum and chrome mining operations.
- Aquatic biomonitoring program for the Valpre bottled water plant (Coca Cola South Africa).
- Aquatic biomonitoring program for industrial clients in the paper production and energy generation industries.
- Aquatic biomonitoring programs for the City of Tshwane for all their Waste Water Treatment Works.
- Baseline aquatic ecological assessments for numerous mining developments.
- Baseline aquatic ecological assessments for numerous residential commercial and industrial developments.
- Baseline aquatic ecological assessments in southern, central and west Africa.
- Lalini Dam assessment with focus on aquatic fish community analysis.
- Musami Dam assessment with focus on the FRAI and MIRAI aquatic community assessment indices.

Wetland delineation and wetland function assessment

- Wetland biodiversity studies for three copper mines on the copper belt in the Democratic Republic of the Congo.
- Wetland biodiversity studies for proposed mining projects in Guinea Bissau, Liberia and Angola in West Africa.
- Terrestrial and wetland biodiversity studies for developments in the mining industry.
- Terrestrial and wetland biodiversity studies for developments in the residential commercial and industrial sectors.
- Development of wetland riparian resource protection measures for the Hartbeespoort Dam as part of the Harties Metsi A Me integrated biological remediation program.
- Priority wetland mammal species studies for numerous residential, commercial, industrial and mining developments throughout South Africa.

Terrestrial ecological studies and biodiversity studies

- Development of a biodiversity offset plan for Xstrata Alloys Rustenburg Operations.
- Biodiversity Action plans for numerous mining operations of Anglo Platinum throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plans for numerous mining operations of Assmang Chrome throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plans for numerous mining operations of Xstrata Alloys and Mining throughout South Africa in line with the NEMBA requirements.
- Biodiversity Action plan for the Nkomati Nickel and Chrome Mine Joint Venture.
- Terrestrial and wetland biodiversity studies for three copper mines on the copperbelt in the Democratic Republic of the Congo.
- Terrestrial and wetland biodiversity studies for proposed mining projects in Guinea Bissau, Liberia and Angola in West Africa.
- Numerous terrestrial ecological assessments for proposed platinum and coal mining projects.

• Numerous terrestrial ecological assessments for proposed residential and commercial property developments throughout most of South Africa. • Specialist Giant bullfrog (*Pyxicephalus adspersus*) studies for several proposed residential and commercial development projects in Gauteng, South Africa. • Specialist Marsh sylph (*Metisella meninx*) studies for several proposed residential and commercial development projects in Gauteng, South Africa. • Project management of several Red Data Listed (RDL) bird studies with special mention of African grass owl (*Tyto capensis*). • Project management of several studies for RDL Scorpions, spiders and beetles for proposed residential and commercial development projects in Gauteng, South Africa. • Specialist assessments of terrestrial ecosystems for the potential occurrence of RDL spiders and owls. • Project management and site specific assessment on numerous terrestrial ecological surveys including numerous studies in the Johannesburg-Pretoria area, Witbank area, and the Vredefort dome complex. • Biodiversity assessments of estuarine areas in the Kwa-Zulu Natal and Eastern Cape provinces. • Impact assessment of a spill event on a commercial maize farm including soil impact assessments.
Fisheries management studies • Tamryn Manor (Pty.) Ltd. still water fishery initiation, enhancement and management. • Verlorenkloof Estate fishery management strategising, fishery enhancement, financial planning and stocking strategy. • Mooifontein fishery management strategising, fishery enhancement and stocking programs. • Wickams retreat management strategising. • Gregg Brackenridge management strategising and stream recalibration design and stocking strategy. • Eljira Farm baseline fishery study compared against DWAF 1996 aquaculture and aquatic ecosystem guidelines.