FRESHWATER ECOLOGY BASELINE AND RISK ASSESSMENT REPORT FOR THE PROPOSED KALGOLD EXPANSION PROJECT

Ratlou Local Municipality, North West

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CLIENT

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1 Introduction

The Biodiversity Company was commissioned to compile a freshwater ecology Environmental Impact Assessment (EIA) for the Kalgold Expansion project. The existing Harmony Kalgold operation wishes to expand its current production from the current production rate of 130 000 tons per month to 300 000 tons per month. A pre-feasibility study has been undertaken. The findings of the pre-feasibility study have concluded that the following new activities and expansions must be provided for:

- New Processing Plant;
- New Powerline;
- New Explosives Magazine;
- Increasing the Pit Footprint;
- Pumping tailings material into the recommissioned TSF;
- Expansion of the Spanover Waste Rock Dump (WRD);
- A Series of new Roads;
- A Series of new Pipelines;
- New Trackless Mobile Machine (TMM) Workshop; and
- New Run of Mine (ROM) Pad.

Kalgold mine is an open pit mining operation located some 60km South-West of Mahikeng in the North West Province. The mine is owned and operated by Harmony Gold, who acquired the mine in 1999. The mine is located in the Kraaipan Greenstone Belt, which is part of the large Amalia-Kraaipan Greenstone terrain. The largest ore body is found in the D-Zone, which was mined out by a single pit operation along a strike length of 1 300 m and to a depth of approximately 290 m below surface. Mining at Kalgold Mine continued at the A-Zone, Windmill and Watertank Open Pits, which are all relatively new opencast operations.

This assessment was conducted in accordance with the amendments to the Environmental Impact Assessment Regulations. 2014 (No. 326, 7 April 2017) of the National Environmental Management Act, 1998 (Act No. 107 of 1998). The approach has taken cognisance of the recently published Government Notice 320 in terms of NEMA dated 20 March 2020: “Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation”.

This report, after taking into consideration the findings and recommendations provided by the specialist herein, should inform and guide the Environmental Assessment Practitioner (EAP) and regulatory authorities, enabling informed decision making with regards to the proposed project.

1.1 Terms of Reference

The Terms of Reference (ToR) included the following:

- Description of the desktop baseline receiving environment specific to the field of expertise (general surrounding area as well as site specific environment);
- Identification and description of any sensitive receptors in terms of relevant specialist disciplines that occur in the project area, and the manner in which these sensitive receptors may be affected by the activity;
- The delineation, classification and assessment of wetlands within 500 m of the project area;
- Determining the ecological status of all potentially affected watercourses;
- The delineation and assessment of any potential sensitive areas;
- An impact assessment for the proposed development; and
- The prescription of mitigation measures and recommendations for identified risks.

1.2 Project Description

Kalgold mine is an open pit mining operation located some 60 km from Mahikeng in the North West Province. The project area is divided by the N18 national highway and falls in the Ratlou Local Municipality within the Ngaka Modiri Molema District Municipality. The area surrounding the project area consists predominantly of mining activities, secondary roads and agricultural fields. The project layout is shown in Figure 1-1, while the location of the project area is shown in Figure 1-2.

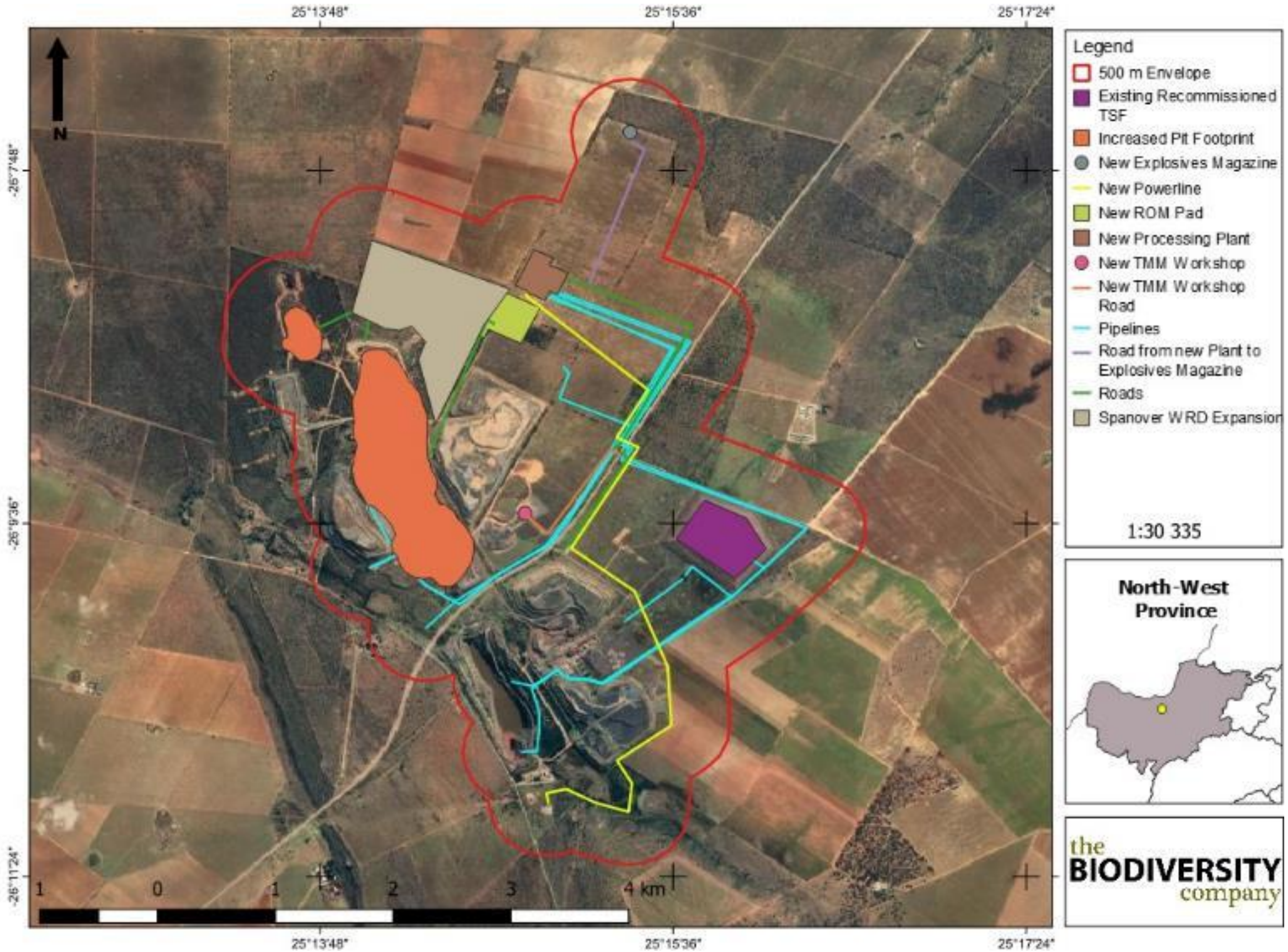

Figure 1-1 Project infrastructure layout

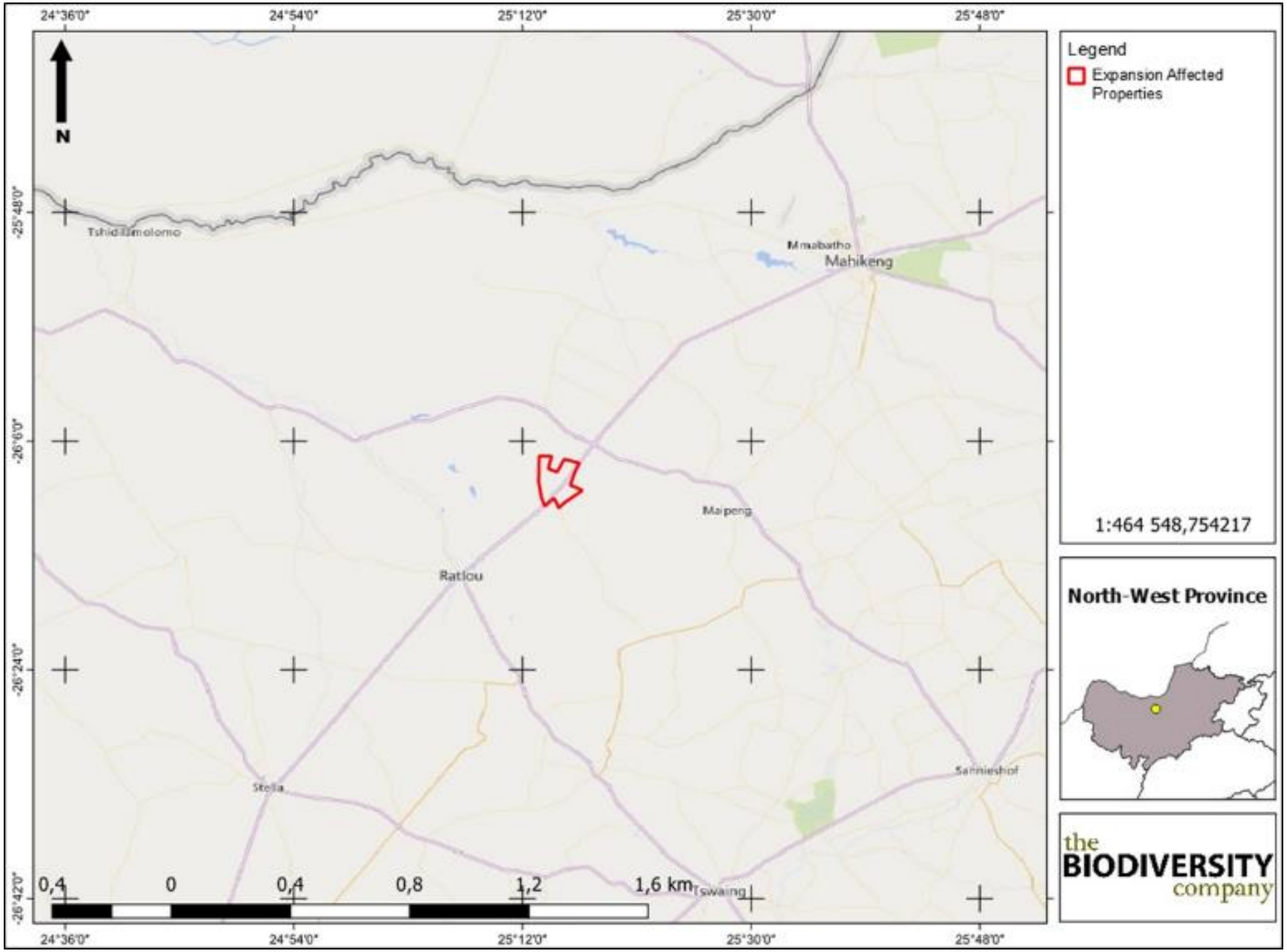

Figure 1-2 Locality of the project area

2 Document Structure

The table below provides the NEMA (2014) Requirements for Ecological Assessments, and also the relevant sections in the reports where these requirements are addressed (Table 2-1).

Table 2-1 Report Structure

Environmental Regulation	Description	Section in Report
NEMA EIA Regulations 2014 (as amended)		
Appendix 6 (1)(a):	Details of – (I) The specialist who prepared the report; and (II) The expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 3
Appendix 6 (1)(b):	A declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix A
Appendix 6 (1)(c):	An indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
Appendix 6 (1)(cA):	An indication of the quality and age of base data used for the specialist report;	Section 6
Appendix 6 (1)(cB):	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 9
Appendix 6 (1)(d):	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 5
Appendix 6 (1)(e):	A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 5
Appendix 6(1)(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 7.3
Appendix 6(1)(g):	An identification of any areas to be avoided, including buffers;	Section 7.3
Appendix 6(1)(h):	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 8
Appendix 6(1)(i):	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 4
Appendix 6(1)(j):	A description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 7
Appendix 6(1)(k):	Any mitigation measures for inclusion in the empr;	Section 10
Appendix 6(1)(l):	Any conditions for inclusion in the environmental authorisation;	Section 10
Appendix 6(1)(m):	Any monitoring requirements for inclusion in the empr or environmental authorisation;	Section 10
Appendix 6(1)(n):	A reasoned opinion- (i) whether the proposed activity, activities or portions thereof should be authorised; (ia) regarding the acceptability of the proposed activity or activities; and (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 11
Appendix 6(1)(o):	A description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
Appendix 6(1)(p):	A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
Appendix 6(1)(q):	Any other information requested by the competent authority.	N/A

3 Specialist Details

Report Name	**FRESHWATER ECOLOGY BASELINE AND RISK ASSESSMENT REPORT FOR THE PROPOSED KALGOLD EXPANSION PROJECT COLLIERY**	
Submitted to	EIMS	
Aquatics Report Writer	**Michael Ryan**	
	Michael Ryan is an Aquatic Ecologist and Hydrologist (Cand. Sci. Nat. 128125). Michael has with 2 years of experience in baseline river assessments and aquatics, with his SASS5 accreditation. Michael Ryan received his B.Sc Honours degree (Geography) from the University of Witwatersrand. Michael specialises in surface water monitoring and aquatic systems and floodline determination. Michael has experience in projects analysing water quality and hydrology which include pipelines; dams; road upgrades; power stations; mining; etc	
Wetland Report Writer	**Ivan Baker**	
	Ivan Baker is Cand. Sci Nat registered (119315) in environmental science and geological science. Ivan is a wetland and ecosystem service specialist, a hydropedologist and pedologist that has completed numerous specialist studies ranging from basic assessments to EIAs. Ivan has carried out various international studies following IFC standards. Ivan completed training in Tools for Wetland Assessments with a certificate of competence and completed his MSc in environmental science and hydropedology at the North-West University of Potchefstroom.	
Report Writer / Reviewer	**Andrew Husted**	
	Andrew Husted is Pr Sci Nat registered (400213/11) in the following fields of practice: Ecological Science, Environmental Science and Aquatic Science. Andrew is an Aquatic, Wetland and Biodiversity Specialist with more than 12 years' experience in the environmental consulting field. Andrew has completed numerous wetland training courses, and is an accredited wetland practitioner, recognised by the DWS, and also the Mondi Wetlands programme as a competent wetland consultant.	
Declaration	The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Environmental Impact Assessment Regulations, 2017. We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time and budget) based on the principals of science.	

4 Key Legislative Requirements

4.1 National Water Act (NWA, 1998)

The Department of Water and Sanitation (DWS) is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The National Water Act (Act No. 36 of 1998 – NWA) allows for the protection of water resources, which includes:

- The maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- The prevention of the degradation of the water resource; and
- The rehabilitation of the water resource.

A watercourse means;

- A river or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

The NWA recognises that the entire ecosystem and not just the water itself, and any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse unless it is authorised by the DWS. The DWS published General Notice (GN) 509. (Government Gazette (GG) no. 40229 under Section 39 of the National Water Act (Act no. 36 of 1998) in August 2016) to facilitate a Water Use Licence (WUL) in terms of Section 21(c) & (i) water uses. These water uses are within the 500 m edge of a wetland, this area known as the regulated area. Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DWS in terms of Section 21 (c) and (i).

4.2 National Environmental Management Act (NEMA, 1998)

The National Environmental Management Act (Act No. 107 of 1998 – NEMA) and the associated Regulations as amended in April 2017, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation application process needs to be followed. This could follow either the Basic Assessment (BA) process or the Environmental Impact Assessment (EIA) process depending on the scale of the impact.

In addition to the above, the assessment will also take cognisance of the following relevant national legislation, conventions and regulations applicable to wetlands and riparian zones:

- Convention on Wetlands of International Importance - the Ramsar Convention and the South African Wetlands Conservation Programme (SAWCP);
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004);

- National Environment Management Protected Areas Act, 2003 (Act 57 of 2003);
- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983);
- South African Water Quality Guidelines under the NWA;
- Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002); and
- GN R267 (Regulations Regarding the Procedural Requirements for Water Use Licence Applications and Appeals)

5 Study Approach

The following approach (or methods) were implemented for the baseline and impact assessment phase of the project, following, and/or including the field survey conducted from the 20th to the 23rd of September 2021. This constitutes a low flow survey.

5.1 Wetland Ecology

The National Wetland Classification Systems (NWCS) developed by the South African National Biodiversity Institute (SANBI) was considered for this assessment. This system comprises a hierarchical classification process of defining a wetland based on the principles of the hydrogeomorphic (HGM) approach at higher levels, and then includes structural features at the lower levels of classification (Ollis *et al.*, 2013).

5.1.1 Wetland Delineation

The wetland areas was delineated in accordance with the DWAF (2005) guidelines, a cross section is presented in Figure 5-1. The outer edges of the wetland areas were identified by considering the following four specific indicators:

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur;
- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation;
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation; and
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

Vegetation is used as the primary wetland indicator. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role.

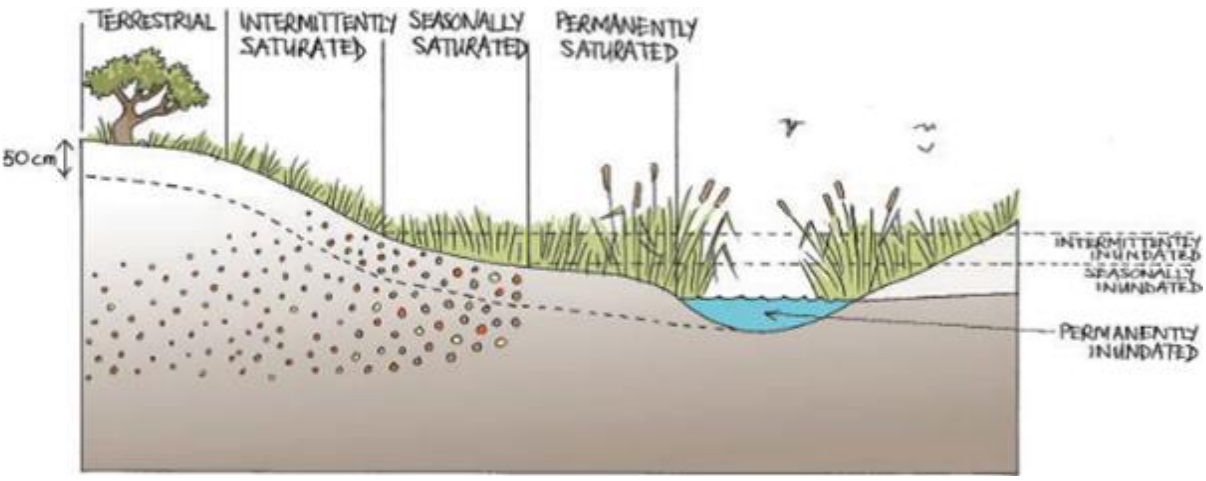

Figure 5-1 Cross section through a wetland, indicating how the soil wetness and vegetation indicators change (Ollis, et al., 2013)

5.1.2 Functional Assessment

Wetland Functionality refers to the ability of wetlands to provide healthy conditions for the wide variety of organisms found in wetlands, as well as for humans. Ecosystem services serve as the main factor contributing to wetland functionality.

The assessment of the ecosystem services supplied by the identified wetlands were conducted per the guidelines as described in WET-EcoServices (Kotze, *et al*. 2009). An assessment were undertaken that examines and rates the following services according to their degree of importance and the degree to which the services are provided (Table 5-1).

Table 5-1 Classes for determining the likely extent to which a benefit is being supplied

Score	Rating of likely extent to which a benefit is being supplied
< 0.5	Low
0.6 - 1.2	Moderately Low
1.3 - 2.0	Intermediate
2.1 - 3.0	Moderately High
> 3.0	High

5.1.3 Present Ecological Status

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present Ecological Status (PES) score. This takes the form of assessing the spatial extent of impact of individual activities/occurrences and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact. The PES categories are provided in Table 5-2.

Table 5-2 The Present Ecological Status categories (Macfarlane, et al., 2009)

Impact Category	Description	Impact Score Range	PES
None	Unmodified, natural	0 to 0.9	A
Small	**Largely Natural** with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1.0 to 1.9	B

Moderate	**Moderately Modified.** A moderate change in ecosystem processes and loss of natural habitats has taken place, but the natural habitat remains predominantly intact.	**2.0 to 3.9**	**C**
Large	**Largely Modified.** A large change in ecosystem processes and loss of natural habitat and biota has occurred.	**4.0 to 5.9**	**D**
Serious	**Seriously Modified.** The change in ecosystem processes and loss of natural habitat and biota is great, but some remaining natural habitat features are still recognizable.	**6.0 to 7.9**	**E**
Critical	**Critical Modification.** The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	**8.0 to 10**	**F**

5.1.4 Ecological Importance and Sensitivity

The importance and sensitivity of water resources is determined to establish resources that provide higher than average ecosystem services, biodiversity support functions or are particularly sensitive to impacts. The mean of the determinants is used to assign the Importance and Sensitivity (IS) category as listed in Table 5-3 (Rountree, M. & Kotze, D. 2013).

Table 5-3 Description of Ecological Importance and Sensitivity categories

EIS Category	Range of Mean	Recommended Ecological Management Class
Very High	3.1 to 4.0	**A**
High	2.1 to 3.0	**B**
Moderate	1.1 to 2.0	**C**
Low Marginal	< 1.0	**D**

5.2 Aquatic Ecology

Standard methods were used to establish the baseline conditions of the considered river reaches. Details pertaining to the specific methodologies applied are provided in the relevant sections below. The various sections provided below elaborate on the various methods/indexes which were applied for this study.

5.2.1 Water Quality

Water quality was measured *in-situ* using a handheld calibrated Extech ExStik II meter. The constituents considered that were measured included: pH, conductivity (µS/cm), temperature (°C) and Dissolved Oxygen (DO) in mg/l.

5.2.2 Aquatic Habitat Integrity and Riparian Zone Delineation

The Intermediate Habitat Assessment Index (IHIA) as described in the Procedure for Rapid Determination of Resource Directed Measures for River Ecosystems (Section D, 1999) was used to define the ecological status of the river reach. This was applied to a 5km reach of the Morokwa River which potentially will be affected by the Kalgold expansion.

The IHIA model was used to assess the integrity of the habitats from a riparian and instream perspective. The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). The criteria and ratings utilised in the assessment of habitat integrity in the current study are presented in Table 5-4 and Table 8-6.

Table 5-4 Criteria used in the assessment of habitat integrity (Kleynhans, 1996)

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or alternatively agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments.
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also, a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

Table 5-5 Descriptions used for the ratings of the various habitat criteria (Kleynhans, 1996)

Impact Category	Description	Score
None	No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

5.2.3 Riparian Delineation

The riparian delineation was completed according to the then Department of Water Affairs and Forestry (DWAF, 2005) procedure for identification and delineation of wetlands and riparian areas. Typical riparian cross sections and structures are provided in Figure 5-2. Indicators such as topography and vegetation will be the primary indicators used to define the riparian zone.

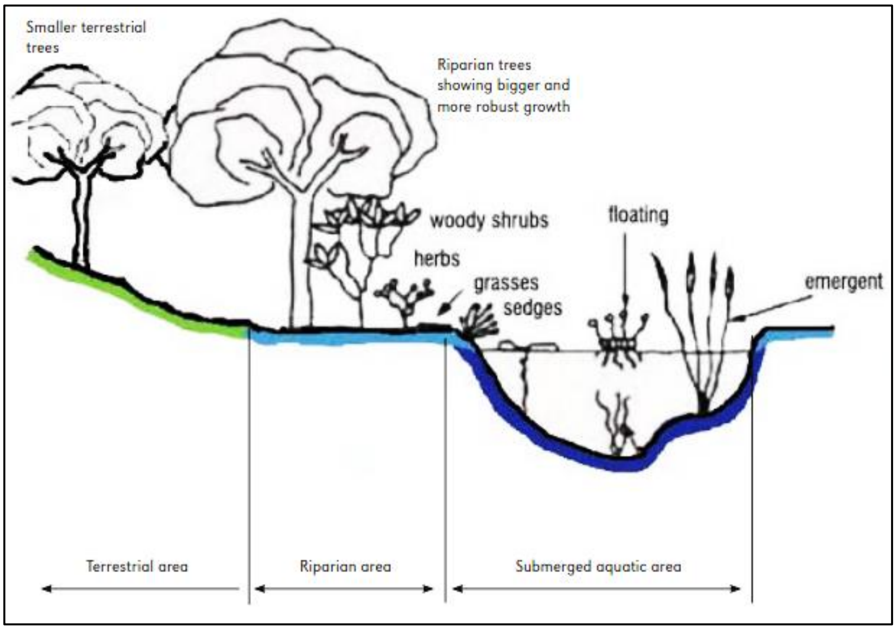

Figure 5-2 Riparian Habitat Delineations (DWAF, 2005)

5.2.4 Aquatic Macroinvertebrate Assessment

Macroinvertebrate assemblages are good indicators of localised conditions because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life. They are particularly well-suited for assessing site-specific impacts (upstream and downstream studies) (Barbour *et al.,* 1999). Benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects (Barbour *et al.,* 1999). The assessment and monitoring of benthic macroinvertebrate communities forms an integral part of the monitoring of the health of an aquatic ecosystem.

5.2.4.1 Invertebrate Habitat

The invertebrate habitat at the site was assessed using the South African Scoring System version 5 (SASS5) biotope rating assessment as applied in Tate and Husted (2015). A rating system of 0 to 5 was applied, 0 being not available. The weightings for lowland rivers (slope class F) were used to categorize biotope ratings (Rowntree et al. 2000; Rowntree and Ziervogel, 1999).

5.2.4.2 South African Scoring System

The South African Scoring System version 5 (SASS5) is the current index being used to assess the status of riverine macroinvertebrates in South Africa. According to Dickens and Graham (2002), the index is based on the presence of aquatic invertebrate families and the perceived sensitivity to water quality changes of these families. Different families exhibit different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Chironomidae) to highly sensitive families (e.g. Perlidae). SASS results are expressed both as an index score (SASS score) and the Average Score Per Recorded Taxon (ASPT value).

Sampled invertebrates were identified using the “Aquatic Invertebrates of South African Rivers” Illustrations book, by Gerber and Gabriel (2002). Identification of organisms will be made to family level (Thirion *et al.,* 1995; Dickens and Graham, 2002; Gerber and Gabriel, 2002).

All SASS5 and ASPT scores are compared with the SASS5 Data Interpretation Guidelines (Dallas, 2007) for the Southern Kalahari ecoregion (Figure 5-3). This method seeks to develop biological bands depicting the various ecological states and is derived from data contained within the Rivers Database and supplemented with other data not yet in the database.

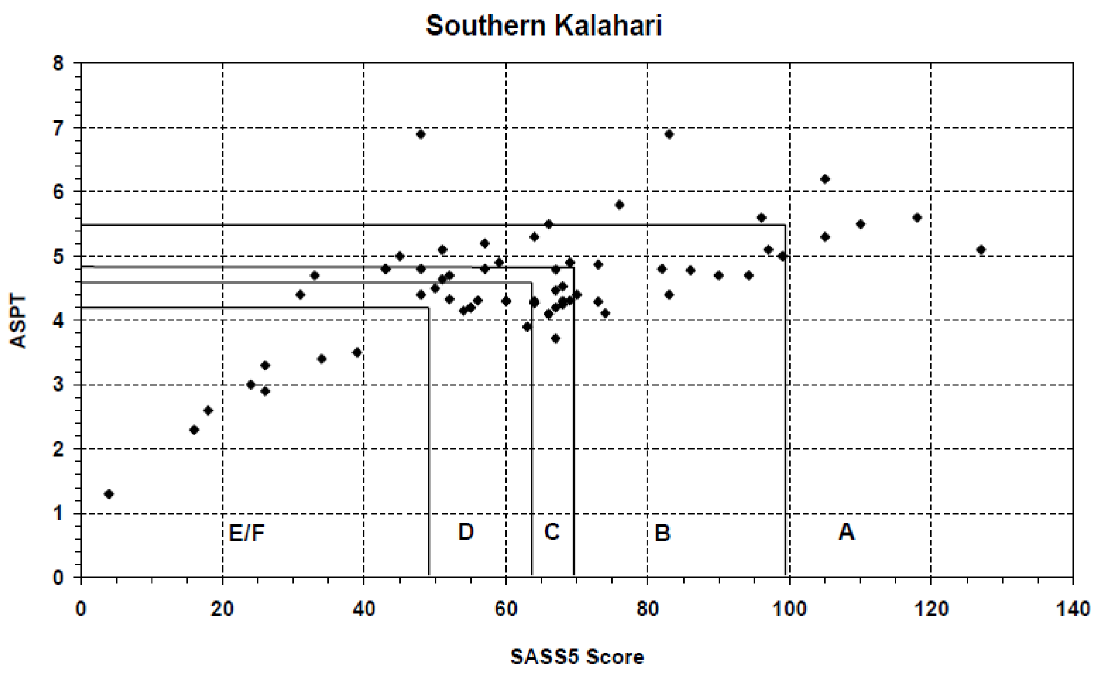

Figure 5-3 Biological Bands for the Southern Kalahari Ecoregion (Dallas, 2007)

5.2.4.3 Macroinvertebrate Response Assessment Index

The Macroinvertebrate Response Assessment Index (MIRAI) was used to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community from the calculated reference conditions for the SQR. This does not preclude the calculation of SASS5 scores if required (Thirion, 2007). The four major components of a stream system that determine productivity for aquatic macroinvertebrates are as follows:

- Flow regime;
- Physical habitat structure;
- Water quality; and
- Energy inputs from the watershed.

The results of the MIRAI will provide an indication of the current ecological category and therefore assist in the determination of the PES.

5.2.5 Fish Community Assessment

A standard qualitative fish assessment was completed for this study making use of rapid electrofishing techniques to determine the reach based fish community during the survey for comparative purposes and interpretation.

5.2.6 Fish Response Assessment Index

Fish have different sensitivities or levels of tolerance to various aspects that they are subjected to within the aquatic environment. These tolerance levels are rated with a sensitivity score as presented in Table 5-6. These tolerance levels are scored to show each fish species' sensitivity to flow and physico-chemical modifications. This applies as an average of the whole class and not each individual species.

Table 5-6 Intolerance rating and sensitivity of fish species

Sensitivity Score	Tolerance/Sensitivity Level
0-1	Highly tolerant = Very low sensitivity
1-2	Tolerant = Low sensitivity
2-3	Moderately tolerant = Moderate sensitivity
3-4	Moderately intolerant = High sensitivity
4-5	Intolerant = Very high sensitivity

Biological responses are important to consider and therefore the qualitative data obtained from the surveys was utilized in the Fish Response Assessment Index (FRAI) (Kleynhans, 2007) and with the results presented below (Table 5-6). The Frequency of Occurrence (FROC) of the sampled fish community is calculated as follows: 0 = Absent; 1 = Present at very few sites (<10%); 2 = Present at few sites (>10-25%); 3 = Present at about >25-50% of sites; 4 = Present at most sites (>50- 75%); 5 = Present at almost all sites (>75%).

The results of the FRAI will provide an indication of the current ecological category and therefore assist in the determination of the PES.

5.2.7 Present Ecological Status

Ecological classification refers to the determination and categorisation of the integrity of the various selected biophysical attributes of ecosystems compared to the natural or close to natural reference conditions (Kleynhans and Louw, 2007). For the purpose of this study ecological classifications will be determined for biophysical attributes for the associated watercourse. This was completed using the river ecoclassification manual by Kleynhans and Louw (2007).

5.3 Buffer Determination

The "Buffer zone guidelines for wetlands, rivers, and estuaries" (Macfarlane, *et al.,* 2014) were used to determine the appropriate buffer zone for the proposed activity.

5.4 Limitations

The following limitations should be noted for the study:

- A single aquatic ecology survey was completed for this assessment. Thus, temporal trends were not investigated;
- Significant modifications to delineated wetlands were identified, which have altered some of these systems to such an extent that identification and delineations are limited in accuracy by artificial influences;

- No baseline biomonitoring data/report(s) are available for the project area. Therefore, information presents the findings of the single aquatic survey;
- Due to the rapid nature of the assessment and the survey methods applied, fish diversity and abundance was likely to be underestimated;
- Dry conditions of the Morokwa River at the time of sampling, the Aquatic Macroinvertebrate Assessment, Fish Community Assessment and Present Ecological Status could not be conducted for the project area;
- Probe malfunction with regards to the Electrical Conductivity for water quality measurements. This was therefore substituted with data received from the client; and
- Ex - situ chemical analysis received from the client were missing some dates and/or sites which resulted from dry sites or lack of access.

6 Receiving Environment

6.1 Climate

The project area is characterised by summer rainfall with very dry winters. The mean annual precipitation (MAP) is about 400–480 mm. There is frost frequent in winter, Mucina & Rutherford (2006), see Figure 6-1.

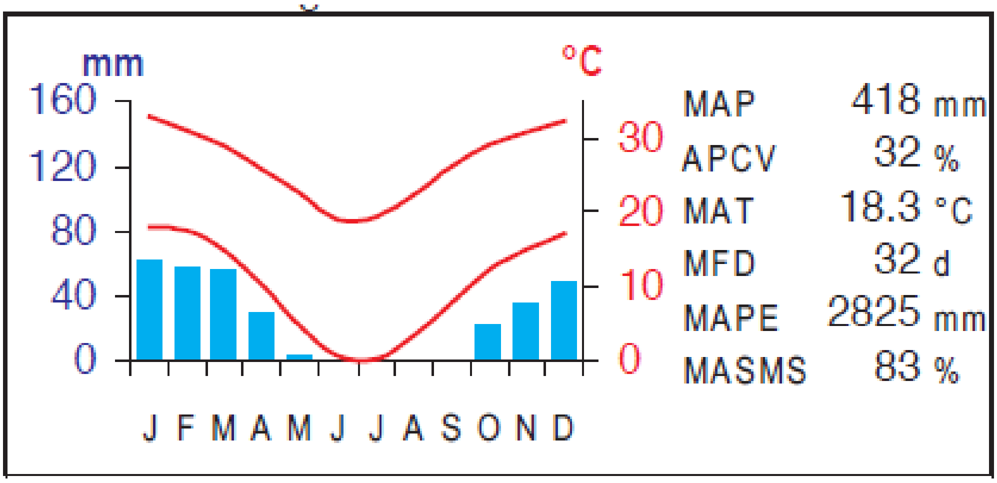

Figure 6-1 Climate diagram for the region, Mucina & Rutherford (2006).

6.2 Soils and Geology

According to the land type database (Land Type Survey Staff, 1972 - 2006), the project area is characterised by the Ae29, Ah17 and Ai3 land types (Figure 6-5). The Ae land type consists of red-yellow apedal soils which are freely drained. The soils tend to have a high base status and is deeper than 300 mm. The Ah land type is characterised by freely drained red-yellow apedal soils with a high base status. The soils within this land type are characterised by less than 15% clay. The Ai land type is characterised by red and yellow-apedal, freely drained soils. These soils are characterised by a high base status usually with a clay percentage of lower than 15.

For the Ae 29 land type, Figure 6-2 illustrates the respective terrain units relevant to the Bb21 land type with the expected soils illustrated in Table 6-1. The figures and tables to follow illustrate these findings for the Ah17 and Ai3 land types respectively.

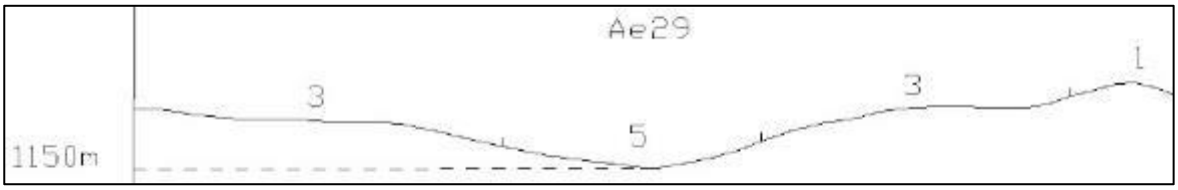

Figure 6-2 Illustration of the Ae 29 land type terrain units (Land Type Survey Staff, 1972 - 2006)

Table 6-1 Soils expected at the respective terrain units within the Ae 29 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units					
1 (1%)		3 (80%)		5 (19%)	
Bare Rock	100%	Hutton	98%	Willowbrook	35%
		Shortlands	2%	Rensburg	25%
				Streambeds	25%
				Milkwood	15%

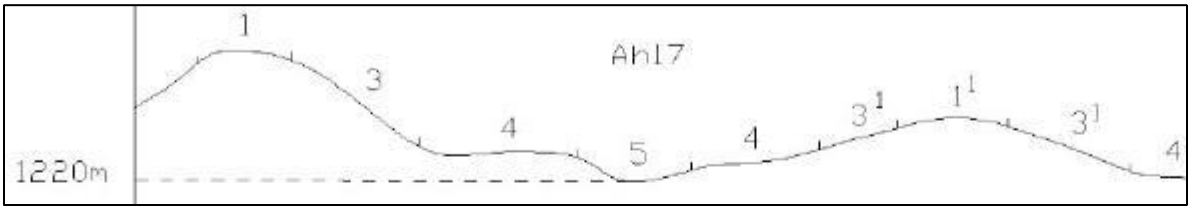

Figure 6-3 Illustration of the Ah 17 land type terrain units (Land Type Survey Staff, 1972 - 2006)

Table 6-2 Soils expected at the respective terrain units within the Ah 17 land type (Land Type Survey Staff, 1972 - 2006)

Terrain units							
1 (22%)		3 (31%)		4 (42%)		5 (5%)	
Hutton	100%	Hutton	50%	Clovelly	88%	Milkwood	55%
		Clovelly	47%	Avalon	12%	Willowbrook	25%
		Avalon	3%			Streambeds	20%

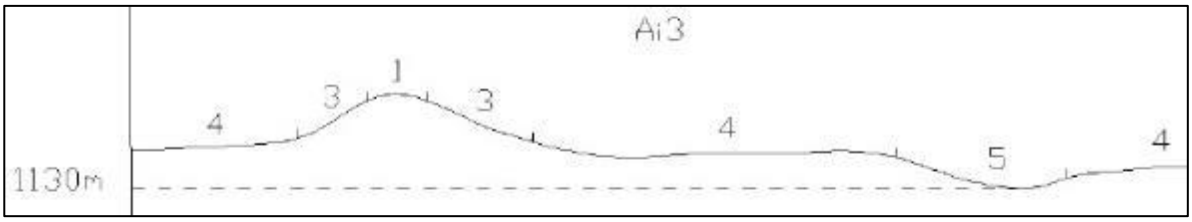

Figure 6-4 Illustration of the Ai 3 land type terrain units (Land Type Survey Staff, 1972 - 2006)

Table 6-3 *Soils expected at the respective terrain units within the Ai 3 land type (Land Type Survey Staff, 1972 - 2006)*

Terrain Units			
4 (42%)		**5 (5%)**	
Clovelly	64%	Milkwood	60%
Fernwood	30%	Fernwood	30%
Hutton	6%	Hutton	10%

According to Mucina & Rutherford (2006), the geology and soils aspect of this region is characterised by red to yellow sandy soils of the Ba and Bb land type. The geology of this region includes sandstone and shale of the Madzaringwe Formations (Karoo Supergroup).

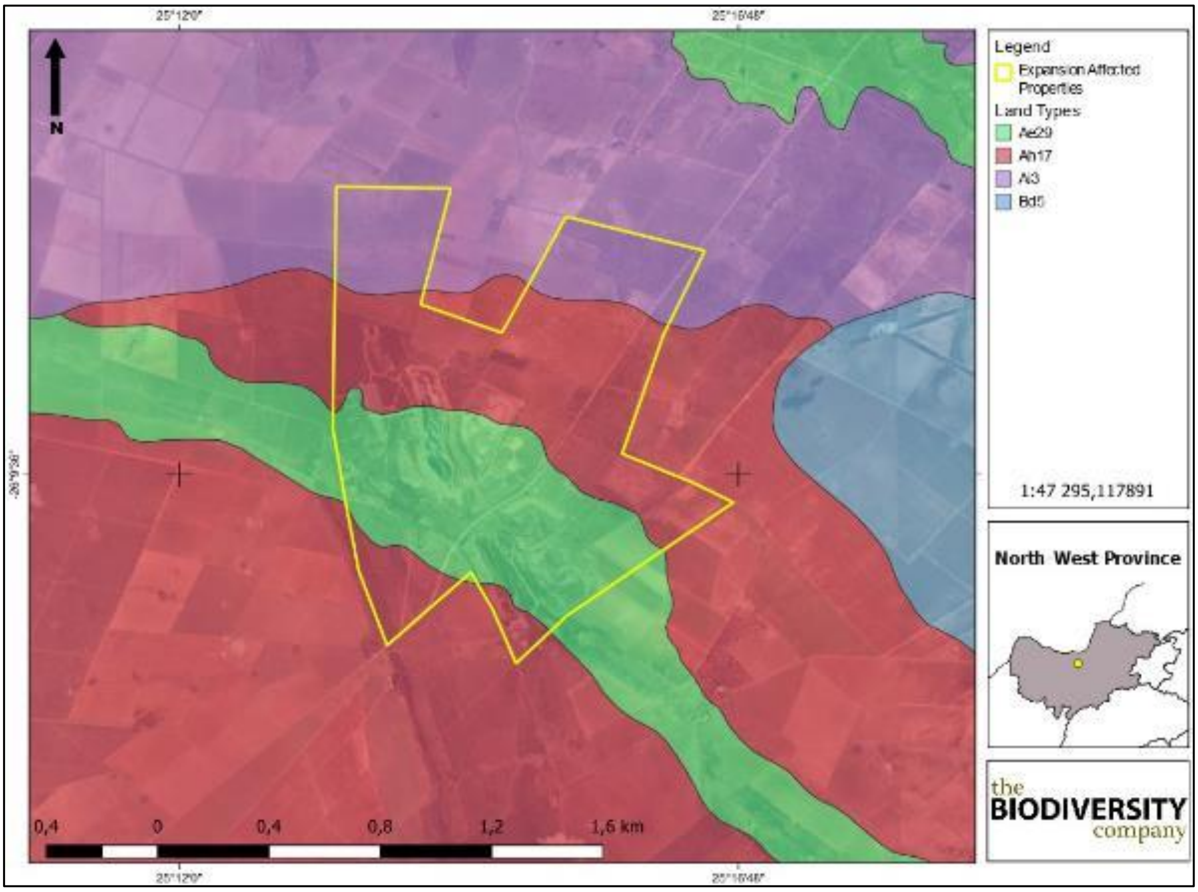

Figure 6-5 The land types associated with the project area

6.3 Vegetation Types

The site is situated in the Savanna biome. The savanna vegetation of South Africa represents the southernmost extension of the most widespread biome in Africa (Mucina & Rutherford, 2006). The savanna biome comprises many different vegetation types. The project area is situated within one vegetation type, namely the Mafikeng Bushveld according to Mucina & Rutherford (2006).

Mafikeng Bushveld (SVk1) is found in the North West province, in Aeolian Kalahari sand of Tertiary to Recent age on flat sandy plains. This vegetation type has well developed tree and shrub layers, dense stands of *Terminalia sericea*, *Acacia luederitzii* and *A. erioloba* in certain areas. The grass layer is also well developed in this vegetation type (Mucina & Rutherford 2006).

The vegetation type is listed as Vulnerable (Mucina & Rutherford, 2006). The conservation target is at 16%. No section of this vegetation type is conserved in statutory conservation areas, but very small area conserved in the Mmabatho Recreation Area. About 25% already transformed, mainly for cultivation and urban development.

6.4 Topographical River Lines

The topographical river line data set from the 2625 quarter degree square was used to identify potential convex features and drainage features. One main non-perennial system is located to the southern portion of the 500 m regulated area (see Figure 6-6).

6.5 NFEPA Wetlands

The National Freshwater Ecosystem Priority Areas (Nel *et al.*, 2011) where used to determine the presence of NFEPA wetlands. Various NFEPA wetland systems were identified to the southern portion of the 500 m regulated area, of which some have been classified as being artificial (dams) (see Figure 6-6).

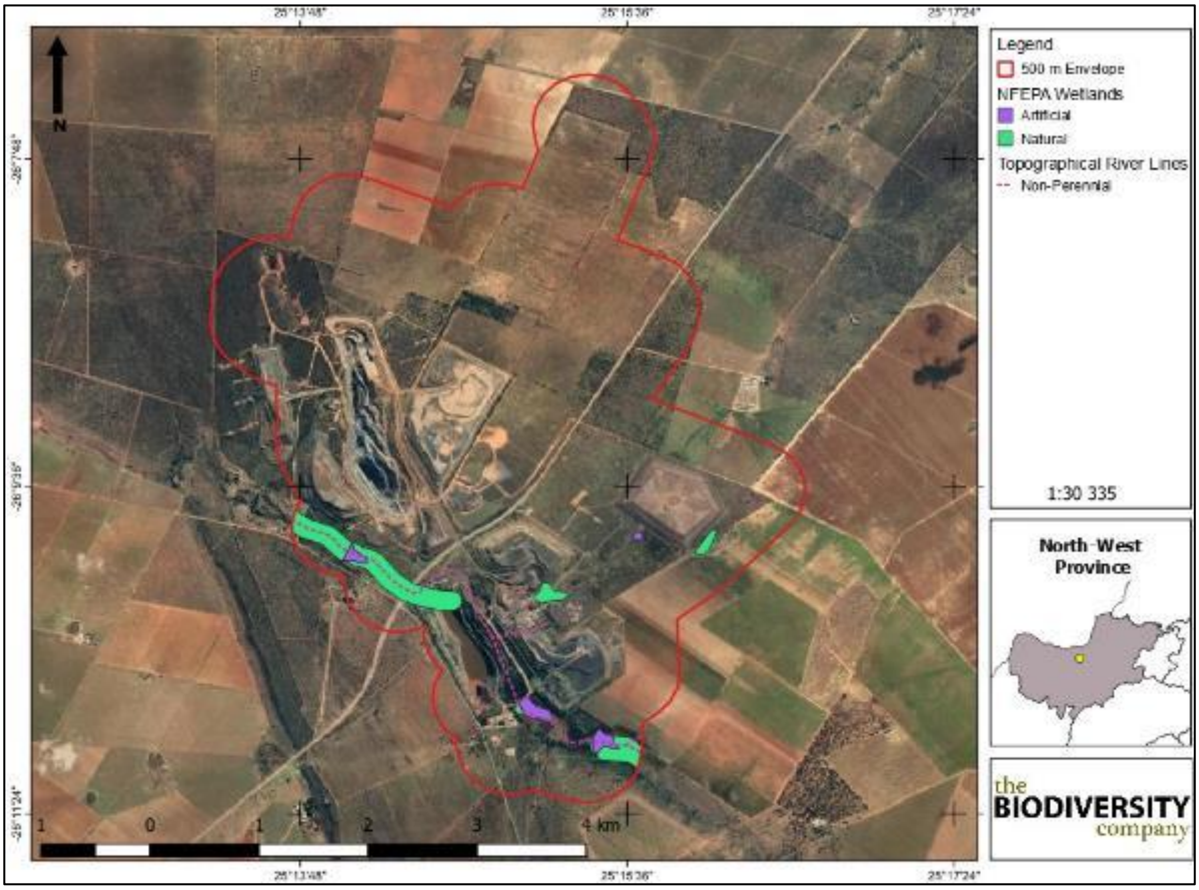

Figure 6-6 Illustration of the NFEPA wetlands and topographical river lines identified within the 500 m development envelop

6.6 South African Inventory of Inland Aquatic Ecosystems

The National Wetland Map 5 spatial data was published in October 2019 (Deventer *et al*. 2019) in collaboration with SANBI with the specific aim of spatially representing the location, type and extent of wetlands in South Africa. The data represents a synthesis of a wide number of official watercourse data including rivers, inland wetlands and estuaries. This database does recognise the presence of four natural wetland types within the 500 m regulated, namely a seep, a floodplain, a depression and a river system (Figure 6-7). The threat status of these systems ranges from Least Concern to Critically Endangered. The projection level ranges from Not Protected to Poorly Protected.

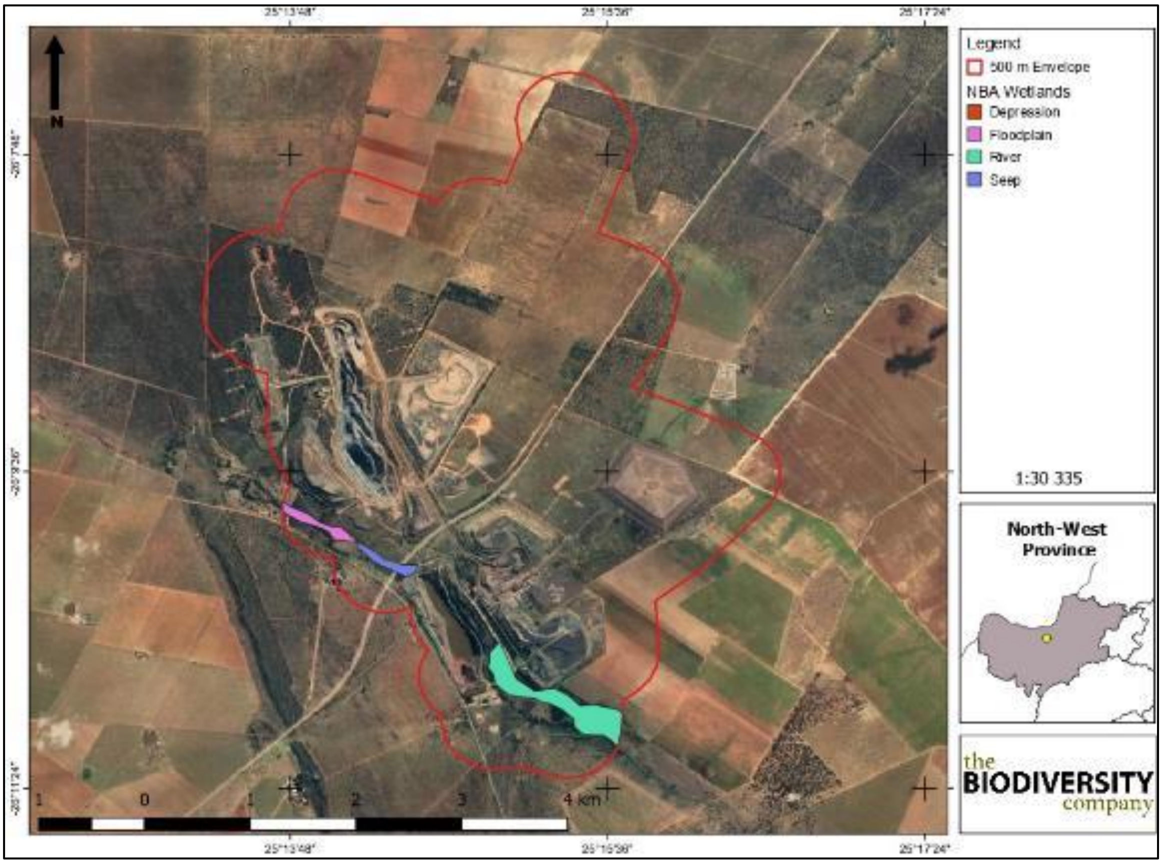

Figure 6-7 National Wetland Map 5

6.7 Strategic Water Source Areas

The Strategic Water Source Areas (SWSA) dataset outlines the surface water of South Africa as defined by the Water Research Commission (WRC) project (K5/2431) (WRC, 2017). Surface water SWSAs are defined as areas of land that supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size. The project area is approximately 2.2 km from the closest SWSA.

6.8 Catchments

The proposed project area is situated in the D41B quaternary catchment within the Vaal Water Management Area (WMA 5) (NWA, 2016) and the Southern Kalahari (29.01) ecoregion (Dallas, 2007). On a smaller scale the project area is located in the 1291 catchment, with the southern tip of the project area in the 1312 catchment and the northern section in the 1182 catchment. These catchments are considered upper management area for the catchments downstream (1190 and 1122) which are river NFEPAs. As a result, modification should be avoided/mitigated as these management areas feed downstream NFEPAs, with resultant modification causing impacts downstream. The watercourse which flows through the project area is the upper reaches of the Morokwa River within the D41B-1291 Sub Quaternary Reach (SQR). The proposed project is directly associated with the D41B-1291 SQR and will therefore directly affect this reach.

The project area considered in this assessment is located within the Southern Kalahari Freshwater Ecoregion (Abel *et al.*, 2008). In comparison to river systems located north of this watercourse, the aquatic fauna of the considered ecoregion is "lacking in diversity" (Abel *et al.*, 2008). This ecoregion is known to contain approximately 1-19 freshwater fish species of which 1-11 are known to be endemic (Figure 6-8). The rivers in this ecoregion are typically alkaline and turbid and flow briefly after rainfall. The majority of the aquatic habitats in this ecoregion are composed of endorheic pans.

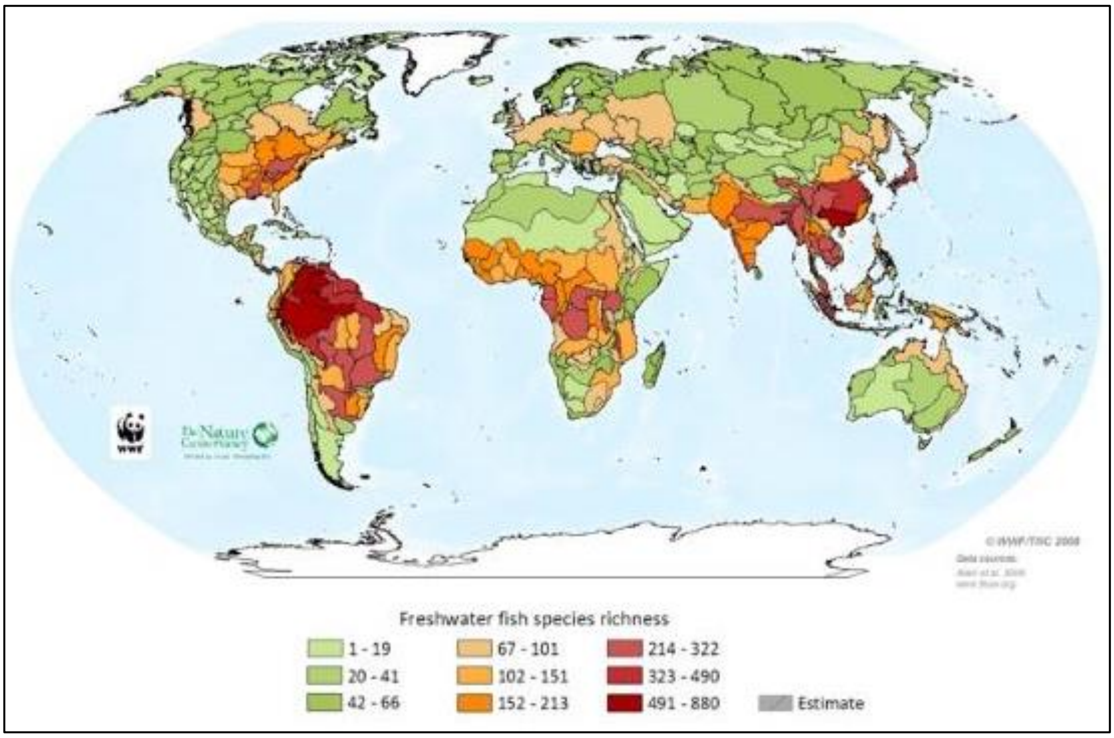

Figure 6-8 Freshwater Fish Species Richness of the Freshwater Ecoregions of the World (Abel et al., 2008)

Notable aquatic ecology in the overall River basin are the several endemic Cyprinid species such as *Labeo capensis* (Least Concern- LC), *L. umbratus* (LC), *Labeobarbus kimberleyensis* (Near Threatened -NT), *Labeobarbus aeneus* (LC) and the Rock Catlet, *Austroglanis sclateri* (LC). The species which are expected to occur in the reach flowing through the project area are represented in Table 6-4. This list includes five species of which one is identified as a Near Threatened (NT) species (*Enteromius brevipinnis*). The expected species are generated on a reach basis, and the occurrence of all species in the system is unlikely as different species are specialists of different habitats which are present along a reach.

Table 6-4 Expected fish species

Species	Common Name	IUCN Status (2021)

Clarias gariepinus	Sharptooth Catfish / Barbel	LC
Enteromius brevipinnis	Shortfin Barb	NT
Enteromius paludinosus	Straightfin Barb	LC
Pseudocrenilabrus philander	Southern Mouthbrooder	LC
Tilapia sparrmanii	Banded Tilapia	LC

LC - Least Concern, NT – Near Threatened, VU - Vulnerable

The desktop ecological status of the D41B-1291 SQR is presented in Table 6-5. The desktop data for the SQR considered in this assessment indicates that the PES of the watercourse is Largely Modified (class D). The central factors negatively effecting the PES include diffuse water quality deterioration, in the form of contaminated surface runoff from agricultural activities, and several instream habitat perturbations in the form of impoundments and mining activities. Further sources of modification including influence from mining with serious habitat loss from mining in the watercourse and flow and channel modification from instream dams and road crossings.

Table 6-5 Desktop Ecological Status of the Morokwa River within the D41B-1291 Sub Quaternary Reach (DWS, 2018)

Present Ecological Status	Largely Modified (class D)
Default Ecological Category (EC)	class C
Ecological Importance	Moderate
Ecological Sensitivity	Moderate

The ecological importance of the watercourse at a desktop level was determined to be moderate. The moderate rated level of importance can be attributed to the wide distribution of aquatic fauna throughout the Orange-Vaal River Basins. The ecological sensitivity was derived to be moderate. The moderate sensitivity was largely attributed to the likely absence of flow reliant taxa.

Considering the identified information at a desktop level the reach of concern flowing through the proposed project area is moderately sensitive to modification with respect to instream biota. Modification has occurred to the system, however fish and macroinvertebrate communities are expected to inhabit the reach which are susceptible to higher levels of modification.

Figure 6-9 Map illustrating fish and river FEPAs for the project area

7 Results and Discussion

7.1 Aquatics Assessment

7.1.1 Sampling Points

The sampling points were selected to adequately assess the current state of the watercourses which are located within the development envelop, to identify the potential risks that may result from the associated development. This was done to gain a holistic understanding of the system and which habitat may be affected.

To achieve this, sites were placed along the D41B-1291 SQR or Morokwa River as well as one of its tributaries which is located to the south of the current Kalgold operation. As a result, site UST was placed along the Morokwa tributary with sites US, MS and DS placed along the Morokwa River. Site DS was moved closer to the Kalgold operations due to lack of access further downstream along the reach. Site Dam 1 to Dam 5 were placed in impoundments along the reach were suspected to have water. The selected sampling location and the location of each crossing can be seen in Table 7-1 as well as Figure 7-1. The *Ex situ* sampling sites are presented in Figure 7-2.

Table 7-1 Photos, co-ordinates and descriptions for the sites sampled (September 2021)

	Upstream	Downstream
Dam 1		
GPS	26° 9'53.75"S 25°13'56.03"E	
Dam 2		
GPS	26° 9'53.75"S 25°13'56.03"E	

	Upstream	Downstream
Dam 3		
GPS	26°10'12.07"S 25°14'46.13"E	
MS		
GPS	26°10'6.49"S 25°14'44.26"E	
DS		
GPS	26° 9'53.75"S 25°13'56.03"E	
Dam 4	NO ACCESS	
GPS	26° 9'41.18"S 25°13'33.76"E	
Dam 5	NO ACCESS	
GPS	26° 9'30.62"S 25°13'7.62"E	

	Upstream	Downstream
UST		
GPS	26°11'3.33"S 25°13'48.75"E	

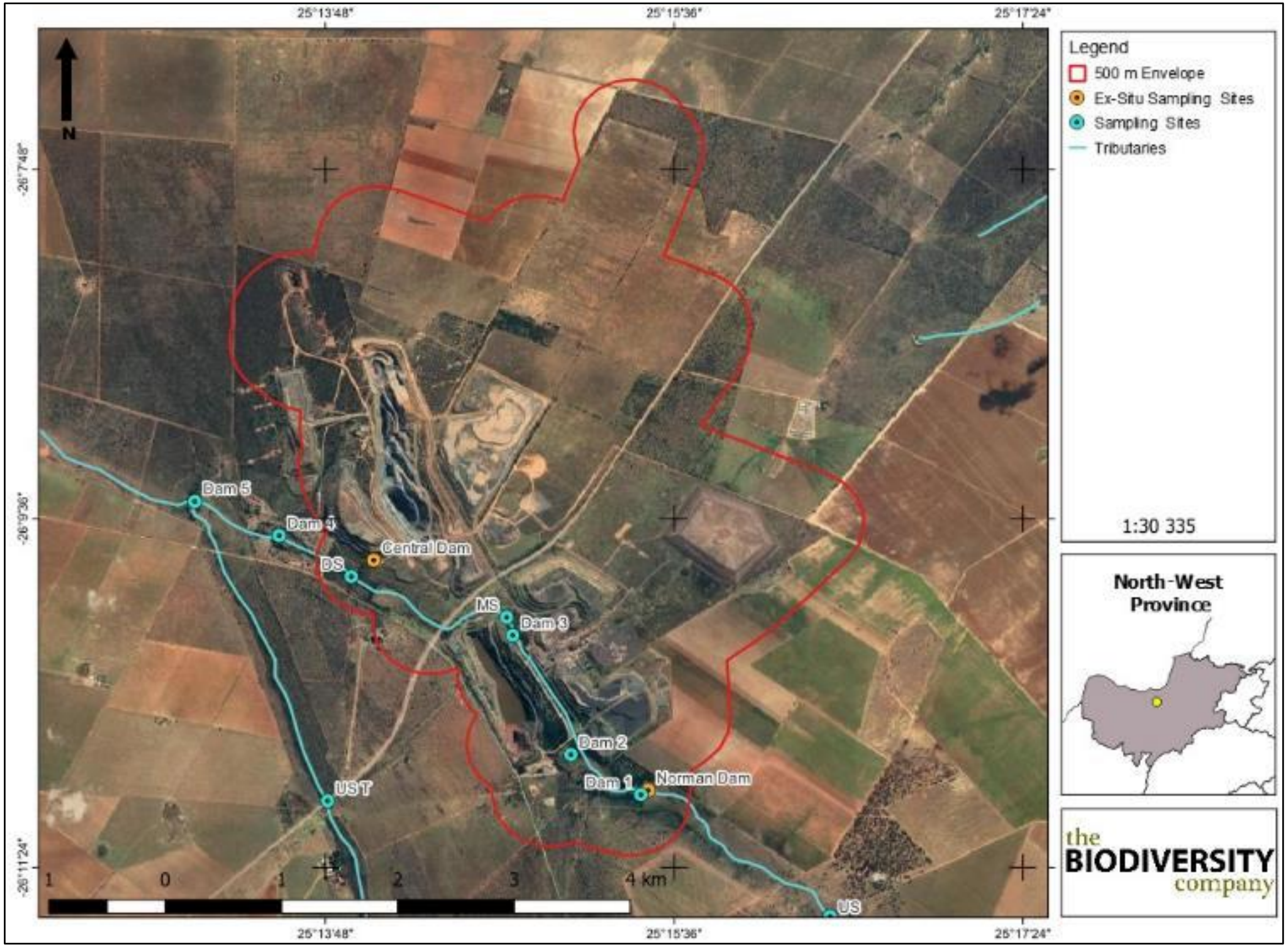

Figure 7-1 Sampling Sites of the project area

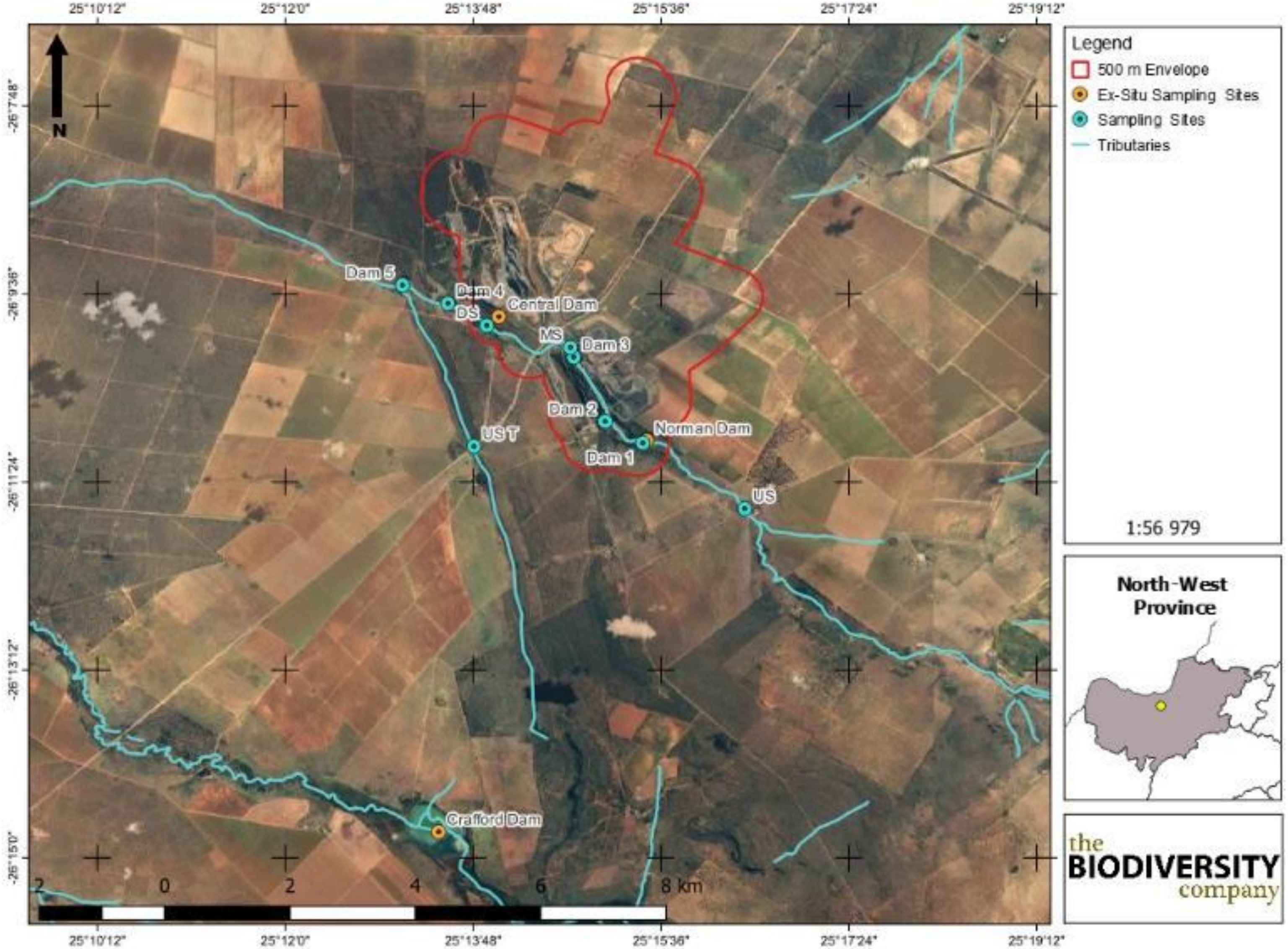

Figure 7-2 Ex-situ sampling sites in relation to the project area

7.1.2 In-situ water quality

In situ water quality analysis was conducted during the assessment on each delignated watercourse within the development envelope. Results have been compared to limits stipulated in the Target Water Quality Range (TWQR) for aquatic ecosystems (DWAF, 1996). The results of the September 2021 assessment are presented in Table 7-2.

Table 7-2: In-situ surface water quality results (September 2021)

Site	pH	Electrical Conductivity (µS/cm)	Dissolved Oxygen (mg/l)	Temperature (°C)
TWQR**	6.5-9.5*	-	>5.00*	5-30*
Dam 1	4.16	*	0.41	27.5
Dam 2	DRY			
Dam 3	DRY			
MS	DRY			
DS	DRY			
Dam 4	NO ACCESS			
Dam 5	NO ACCESS			
UST	DRY			

*TWQR – Target Water Quality Range, * - Water quality meter malfunction

The water quality constituents measured during the assessment were considered modified when compared to guidelines established by DWAF (1996). The pH within Dam 1 is considered acidic at 4.16. Anoxic conditions were observed within the dam with a dissolved oxygen level of 0.41 mg/l. The dam was however reduced to a puddle which is not flowing with stationary water resulting in water degradation as a lack of diluting potential enriches modified parameters. The constituents measured are considered to be a limiting factor for aquatic biota however lack of continuous flow in the system has resulted in no aquatic biota making use of the resource.

7.1.3 Ex-situ water quality

Ex - situ chemical analysis results were received from the client. Monthly samples were sent off for analysis by DD Science. The result of the analysis is presented in Table 7-3. Missing values were not presented but resulted from dry sites or lack of access.

Table 7-3 Ex - situ water analysis for the dams of the project area (October 2020 - July 2021)

Determinant	Units	*Harmony - Kalgold Operations*			CD	CrD	ND	CD	CrD	ND	CD	CrD	ND	CD	CrD	ND	CD	CrD	ND	CD	ND	CD	CrD	ND	CD	ND	CD	CrD
Sample Date		GAZ 20526 Maximum for Waste Water	EMPR Water Quality Objects	SANS 241 (2015) mg/L	10/30/2020	10/30/2020	11/27/2020	11/27/2020	11/27/2020	12/17/2020	12/17/2020	12/17/2020	2/26/2021	2/25/2021	2/25/2021	3/30/2021	3/30/2021	3/30/2021	4/29/2021	4/29/2021	2021/05/27	2021/05/27	2021/05/27	2021-06-30	2021-06-30	2021-07-29	2021-07-29	2021-07-29
Sample ID					26858/13	26858/14	27003/8	27003/11	27003/12	27083/8	27083/11	27083/12	28179/8	28179/11	28179/13	28278/8	28278/11	28278/13	28362/8	28362/11	28459/8	28459/11	28459/13	28583/7	28583/10	28681/8	28681/10	28681/12
pH	@25°C	5.5-9.5	6.0-9.0	5.7-9.7	7.3	8.9	9.0	8.2	8.3	9.0	8.1	8.3	7.6	7.9	8.2	7.5	7.7	8.2	7.3	7.9	7.5	7.8	8.6	7.2	7.3	7.9	7.7	9.8
Conductivity	mS/m @25°C	150		170	163	17	33	193	25	35	190	27	16	157	17	16	178	18	15	174	13	166	12	16	168	38	170	14
Total Dissolved Solids	mg/l@180°C		2000	1 200	1280	139	236	1760	89	242	1820	96	144	1360	94	270	1700	95	131	1730	335	1710	110	370	1610	348	1850	95
Suspended Solids	mg/l@105°C	25			<10	927	207	<10	276	200	<10	250	179	<10	18	61	<10	21	750	<10	216	<10	34	655	<10	494	96	21
Chloride	mg/l		600	300	149	12	10	317	10	14	320	13	24	260	22	10	333	12	11	308	15	311	6.0	21	318	26	316	8.0
Sulphate	mg/l		600	500	106	<40	<40	331	<40	<40	342	<40	<40	191	<40	<40	177	<40	<40	207	<40	267	<40	<40	226	79	244	<40
Total Alkalinity	mg/lCaCO3				87	68	45	128	90	46	137	90	23	199	60	41	138	81	34	230	16	190	62	34	226	45	233	57
***Nitrate**	mg/l N	15		11	12	2.2	4.0	8.2	1.9	4.2	7.9	2.5	3.0	46	0.5	2.8	34	0.6	34	259	13	51	3.5	81	283	14	82	6.9
***Fluoride**	mg/l	1		1.5	0.3	0.7	0.3	0.6	0.5	0.7	0.6	0.4	0.3	0.5	0.2	0.2	0.3	0.1	<0.08	0.4	<0.08	0.2	<0.08	0.1	0.7	0.5	0.4	0.3
***Ammonia**	mg/l N	3			1.1	0.6	2.0	1.3	1.0	2.1	1.1	1.3	1.2	2.2	3.5	1.5	2.8	1.2	1.4	1.7	4.5	2.8	3.3	8.4	8.3	21	2.5	2.1
COD	mg/l	75			237	241	<20	51	<20	<20	58	<20	92	<20	<20	115	68	28	208	72	135	<20	20	485	<20	847	<20	24
***Free CN**	mg/l CN				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0.5	<0.5	<0.5
WAD Cyanide	mg/l CN				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0,5	<0,5	<0,5	<0,5	<0,5	0.7	<0,5	<0.5	<0.5	<0.5
***Calcium**	mg/l			150	151	15	27	150	12	28	158	14	11	166	21	9.4	240	8.8	3.9	228	11	237	13	20	244	33	225	13
*** Magnesium**	mg/l		100	70	59	9.0	30	69	4.8	3.8	76	5.8	11	53	4.2	6.6	70	7.5	1.5	65	5.1	77	4.7	7.8	81	3.6	81	8.4
***Sodium**	mg/l		500		45	17	12	54	11	15	57	16	4.7	66	9.8	11	64	15	10	95	8.8	75	8.8	7.7	80	7.6	72	9.8
***Potassium**	mg/l			50	1.4	1.1	12	2.7	1.6	10	2.8	1.7	6.1	56	1.4	0.1	2.8	0.4	0.3	3.3	0.5	3.0	2.7	11	2.4	22	2.1	1.4
***Iron**	mg/l	0.3		0.3	0.001	0.002	0.001	0.001	0.9	<0.001	<0.001	0.6	0.002	0.005	0.005	0.002	0.005	0.005	0.001	0.007	<0,001	<0,001	0.1	<0,01	<0,01	0.7	0.002	0.2

*Manganese	mg/l	100		0.1	0.0004	0.003	0.009	0.02	0.002	<0.001	0.001	0.001	0.01	0.03	0.002	0.002	0.01	0.01	0.001	0.001	<0,001	<0,001	<0,001	<0,01	<0,01	0.002	<0.001	0.001
*#Aluminium	mg/l				0.001	0.022	<0.001	0.001	0.4	<0.001	0.001	0.001	0.002	0.002	0.003	0.002	0.008	0.004	0.001	0.003	0.001	0.002	0.07	<0,01	<0,001	0.02	0.001	0.3
*#Arsenic	mg/l	20		0.01	0.001	0.001	<0.001	0.006	0.001	<0.001	0.001	0.001	<0.001	0.003	0.002	0.001	0.002	0.002	<0,001	0.002	0.001	0.002	<0,001	<0,01	<0,001	0.004	0.001	0.001
*#Cadmium	mg/l	5			0.0002	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,01	<0,001	<0.001	<0.001	<0.001
*#Cobalt	mg/l			0.5	0.0001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.009	0.006	0.001	0.001	0.001	0.001	0.008	0.001	0.001	<0,001	<0,01	<0,001	0.002	0.001	<0.001
*#Lead	mg/l			0.01	0.0001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,01	<0,001	<0.001	<0.001	<0.001
*#Nickel	mg/l			0.07	0.0009	0.001	0.001	0.004	0.002	<0.001	0.010	0.001	0.001	0.003	0.003	<0.001	0.001	0.001	0.001	0.004	0.002	0.005	0.001	<0,01	<0,001	0.01	0.001	0.003
*#Zinc	mg/l	100		5	0.0004	0.002	0.008	<0.001	0.001	<0.001	0.001	0.001	0.002	0.001	0.002	0.01	0.01	0.001	0.001	0.01	0.004	0.001	0.01	<0,01	<0,001	0.003	<0.001	0.001
*#Mecury	mg/l				0.001	<0.001	191	658	50	226	0.001	0.002	73	632	70	51	888	53	16	837	48	908	52	82	942	97	895	67
*Total hardness	mg/l				619	74	156	4.0	200	170	6.1	220	123	0.7	7.0	68	1.4	8.9	219	0.8	155	1.5	23	2.2	0.3	759	22	27

Norman Dam ND; Central Dam CD, Crafford Dam CrD

An analysis of the water quality parameters tested from the three dams is presented in Figure 7-2 which indicates modification to the systems. Site CrD is not considered relevant as the dam along the Koedoespruit has a large circle of influence, which contour data reveals the Kalgold operation is not part of. Norman Dam co-indices with Dam 1 which indicates a constant elevated Suspended Solids for the monitoring period. April 2021 indicates the beginning of elevated Ammonia and Chemical Oxygen Demand (COD) in the dam which was observed on site during the survey by the low DO observed in September 2021. Along with the observed elevated nitrates within the dam, this indicates a nutrient source which is impacting on the dam. These nutrients cause eutrophication of waterbodies as algae blooms remove all available oxygen from the system. The dam is located upstream of the mining activity and therefore agriculture is the suspected source of the nutrients. Site CD is located along the pit at site MS. It was dry during the September 2021 survey. *Ex - situ* analysis indicates consistent elevated levels of Conductivity and Total Dissolved Solids within the dam. The constituents which comprise these dissolved solids vary throughout the period of monitoring, forming a compounding influence with no single observed constituent identified as a source of modification throughout the monitoring period. This indicates modification which would be a limiting factor for aquatic biota as well as terrestrial biota making use of the system.

7.1.4 Habitat Integrity Assessment

The IHIA was completed for the Morokwa River reach as described in the IHIA methodology component of this study. The special framework of which constitutes a 5km reach of the Morokwa River which would potentially be affected by the Kalgold Expansion Project. The results thereof are shown in Table 7-4.

Table 7-4 Intermediate Habitat Integrity Assessment for the Morokwa River reach (September 2021)

Criterion	Impact Score	Weighted Score
Instream		
Water abstraction	5	2.8
Flow modification	14	7.3
Bed modification	2	1.0
Channel modification	15	7.8
Water quality	12	6.7
Inundation	9	3.6
Exotic macrophytes	0	0.0
Exotic fauna	0	0.0
Solid waste disposal	0	0.0
Total Instream Score		70.76
Instream Category		C
Riparian		
Indigenous vegetation removal	14	7.3
Exotic vegetation encroachment	5	2.4

Bank erosion	5	2.8
Channel modification	13	6.2
Water abstraction	20	10.4
Inundation	6	2.6
Flow modification	17	8.2
Water quality	15	7.8
Total Riparian Score		**52.28**
Riparian Category		**D**

The results of the Habitat Integrity Assessment of the Morokwa River indicates that instream habitat is moderately modified (class C) while the riparian habitat is largely modified (class D). This indicates that the instream habitat has experienced a loss and change of natural habitat and biota but the basic ecosystem functions are still predominantly unchanged while riparian habitat has experienced a large loss of natural habitat, biota and basic ecosystem functions. The surrounding land use of the Morokwa River is presented in Figure 7-3 which is dominated by agriculture with the Kalgold open-pit gold mine surrounding the centre of the reach. The absence of surface flow within the reach hinders the applicability of many parameters considered in the IHIA for instream habitat assessment. The lack of flow results from regional climate combined with abstraction in the upper reaches for agriculture and the lack of flow in the project resulting from subsurface flow which has filled the mining pit presented in . The lack of subsurface flow allows for greater degrees of infiltration within the channel and therefore no surface flow. This diversion also results in significant channel modification due to its artificial nature. The resultant pit required a river diversion seen in Figure 7-4 between the two dirt roads to the north east of the original alignment of the Morokwa River indicated by the blue line. The landuse change to agriculture and mining resulted in large scale vegetation removal with alien invasive encroachment resulting in disturbed areas.

The Kalgold operations which surround the reach have significant amounts of associated infrastructure such as road and dam walls along with pits which have resulted in channel, flow and bed modification. Artificial channelling is caused by roads which focus flow while dams hinder flow causing inundation of the system as seen in Figure 7-5. Instream water quality modification is difficult to measure when the channel is dry however results from dam 3 indicate modification. Riparian influence from surrounding agriculture as well as influence from mining activity have the potential to significantly modify water quality within the reach. *Ex-situ* water quality results indicate the modification to the system from nutrient inputs as well as elevated total salts.

Figure 7-3 Arial imagery of the project area (GoogleEarth, 2021)

Figure 7-4 Channel diversion at the Kalgold operations (Google Earth, 2021)

Figure 7-5 Damming of the Morokwa River (Google Earth, 2019)

7.1.5 Riparian Habitat – Watercourse Extent

Riparian areas have high conservation value and can be considered most important part of a watershed for a wide range of values and resources. They provide important habitat for a large volume of wildlife and often forage for domestic animals. The vegetation they contain are an important part of the water balance for the hydrological cycle through evapotranspiration. They are crucial for riverbank stability and in preventing erosion within the channel (Elmore and Beschta, 1987). Therefore, they are considered as high priority areas and should be avoided at all costs, resulting in the assigned 30m buffer. This is in line with the suggested buffer requirements suggested by Ezemvelo (2013). The delineated riparian area and associated buffer for all watercourses within the 500 m regulated area or the project area is presented in Figure 7-10.

The riparian areas of the Morokwa River and associated tributary were limited by the location and associated climate of the region which results in the ephemeral nature of the watercourse. This is exasperated by underground pumping for mining activities as well as instream dams, which increases the potential for infiltration. This has resulted in a predominantly dry watercourse for multiple years and no discernible difference between terrestrial and riparian vegetation. There were little to no vegetation species located along the reach which indicate wetness within the underlying soil. This is especially true along the section of the reach which was diverted to allow for the pit along the section upstream of site MS. The artificial dug trench is represented in Figure 7-6. The homogeneous nature of the vegetation has resulted in tree species such as *Ziziphus mucronata, Vachellia karroo* (Figure 7-7), *Searsia lancea* (Figure 7-8) and *Buddleja saligna* (Figure 7-9) which dominate the channel banks and have even established in the centre of the channel at locations – indicating the length of no surface flow in the channel. Between these tree species the terrestrial grasses such as *Aristida congesta,* *Eragrostis superba, Cynodon dactylon, Anthephora pubescens* and *Cymbopogon pospischilii* have encroached on the system.

Figure 7-6 Riparian area along the dry river diversion area (September 2021)

Figure 7-7 Vachellia karroo (September 2021)

Figure 7-8 Searsia lancea (September 2021)

Figure 7-9 Buddleja saligna (September 2021)

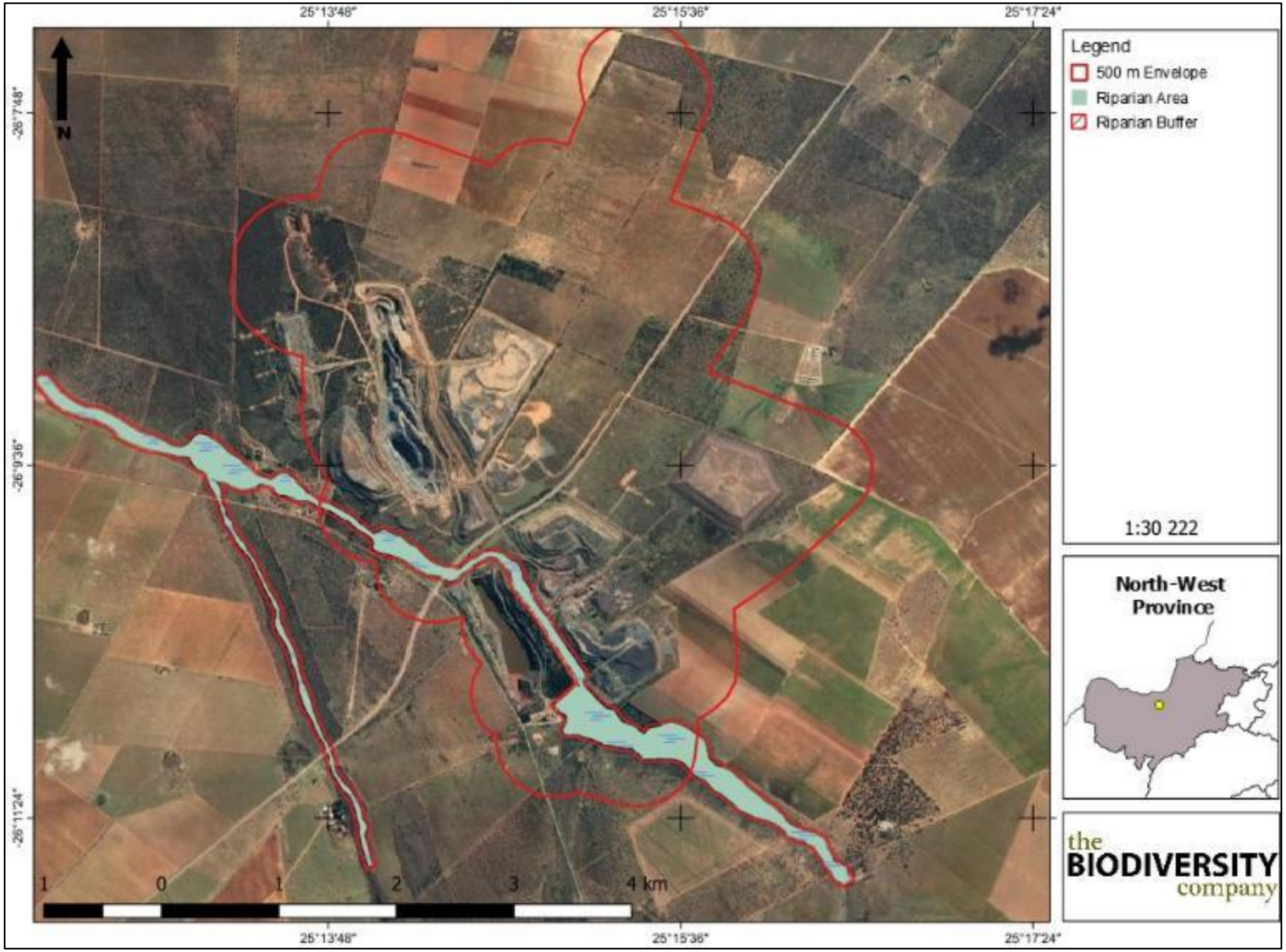

Figure 7-10 Riparian Delineation and associated buffer of the project area

7.1.6 Aquatic Macroinvertebrate Assessment

An Aquatic Macroinvertebrate Assessment could not be conducted due to the lack of surface flow in the Morokwa River.

7.1.7 Fish Community Assessment

No fish were sampled in the Morokwa River as no surface flow was present.

7.1.8 Present Ecological Status

The present ecological state of the Morokwa River could not be calculated without the Macroinvertebrate Response Assessment Index (MIRAI) and/or Fish Response Assessment Index (FRAI) which could not be conducted as a result of the lack of surface flow within the Morokwa River.

7.2 Wetland Assessment

7.2.1 Wetland Delineation and Description

The wetland areas were delineated in accordance with the DWAF (2005) guidelines (see Figure 7-13). Two natural wetland units were identified within the development envelop, namely HGM 1 and 2 (uncharnelled valley bottom wetlands). In addition, some artificial wetlands, drainage features and a riparian system were identified. The latter has comprehensively been assessed during the aquatics baseline assessment. The artificial system has been formed due to continues leaks occurring upstream of the system where dust suppression vehicles refill. This system has therefore been disregarded from this report.

Even though HGM 1 seems to form at the edge of the existing TSF, historic imagery suggests that a wetland system was present before the construction of this facility, hence the classification of natural (see Figure 7-11).

Figure 7-11 Historic imagery (1970's) of the project area

Figure 7-12 Examples of wetlands identified. A) HGM 1. B) Riparian zone

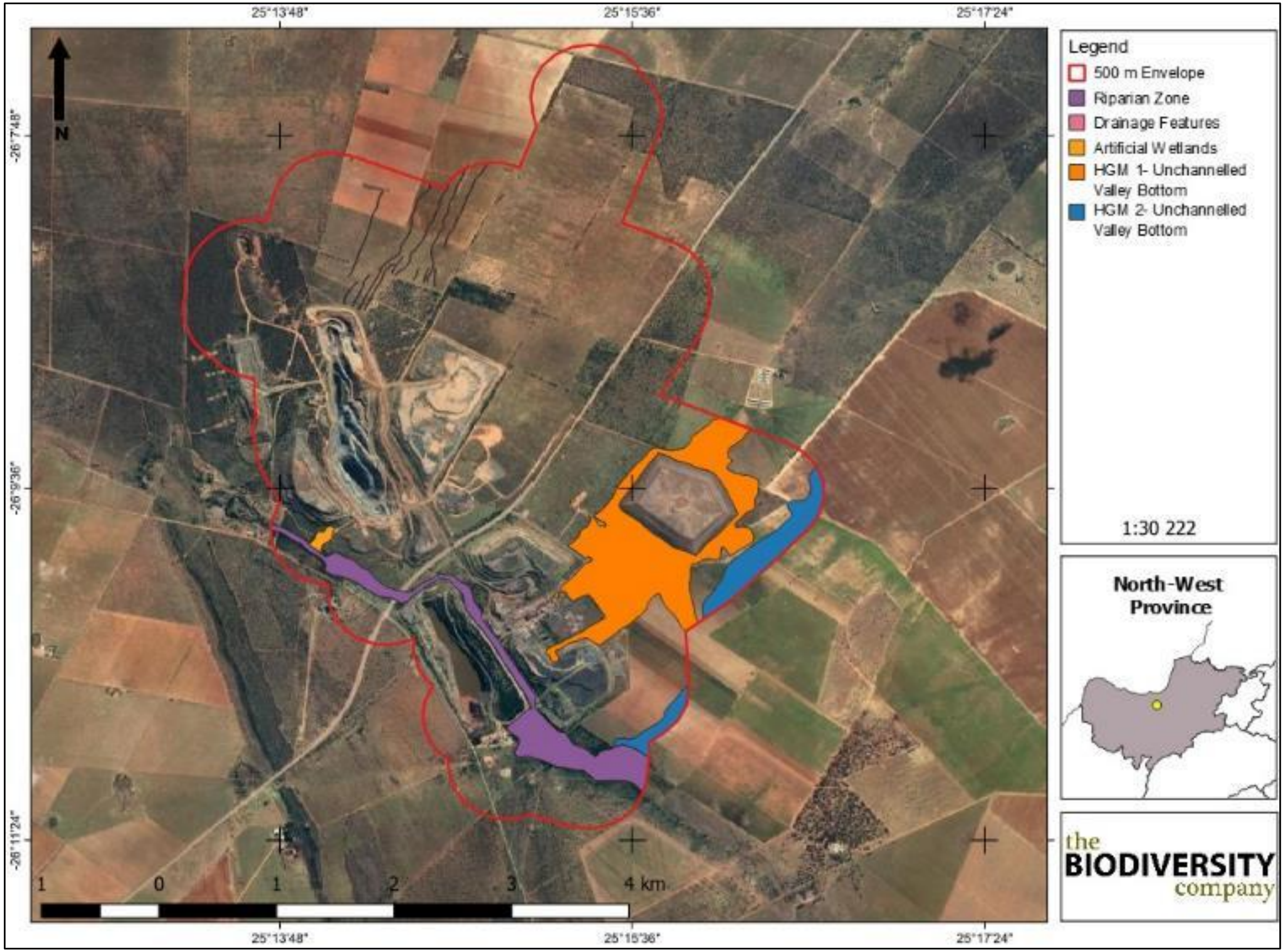

Figure 7-13 Delineation of wetlands within project area

7.2.2 Wetland Unit Identification

The wetland classification as per SANBI guidelines (Ollis *et al.,* 2013) is presented in Table 7-5. Both systems share the same level 1 to 4 classification, DWS ecoregion and NFEPA wet veg groups.

Table 7-5 Wetland classification as per SANBI guideline (Ollis et al. 2013)

Wetland System	Level 1	Level 2		Level 3	Level 4		
	System	DWS Ecoregion/s	NFEPA Wet Veg Group/s	Landscape Unit	4A (HGM)	4B	4C
HGM 1	Inland	Southern Kalahari	Eastern Kalahari Bushveld Group 1	Valley Bottom	UVB	N/A	N/A
HGM 2				Valley Bottom	UVB	N/A	N/A

7.2.3 Wetland Unit Setting

Unchanneled valley bottom wetlands are typically found on valley floors where the landscape does not allow high energy flows. Figure 7-14 presents a diagram of the relevant HGM units, showing the dominant movement of water into, through and out of the system.

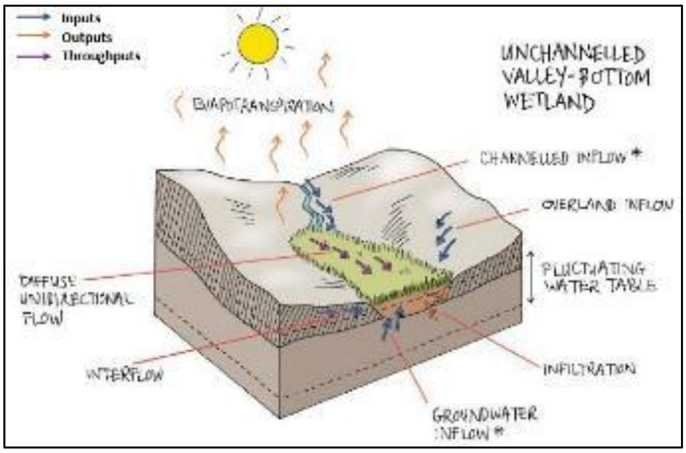

Figure 7-14 Amalgamated diagram of a typical unchanneled valley bottom, highlighting the dominant water inputs, throughputs and outputs, SANBI guidelines (Ollis et al. 2013)

7.2.4 Wetland Indicators

7.2.4.1 Hydromorphic Soils

According to (DWAF, 2005), soils are the most important characteristic of wetlands in order to accurately identify and delineate wetland areas. One dominant soil form was identified within the relevant wetlands, namely the Kroonstad soil form.

The Kroonstad soil form consists of an orthic topsoil on top of an albic horizon, which in turn is underlain by a Gleyic horizon. The soil family group identified for the Kroonstad soil form is "1110" due to the gley colour of the topsoil, the albic horizon's grey colours when in a wet condition as well as the non-calcareous nature of the soil.

Orthic topsoils are mineral horizons that have been exposed to biological activities and varying intensities of mineral weathering. The climatic conditions and parent material ensure a wide range of properties differing from one orthic topsoil to another (i.e. colouration, structure etc) (Soil Classification Working Group, 2018).

Gley horizons that are well developed and have homogenous dark to light grey colours with smooth transitions. Stagnant and reduced water over long periods is the main factor responsible for the formation of a Gley horizon and could be characterised by green or blue tinges due to the presence of a mineral called Fougerite which includes sulphate and carbonate complexes. Even though grey colours are dominant, yellow and/or red striations can be noticed throughout a Gley horizon. The structure of a Gley horizon mostly is characterised as strong pedal, with low hydraulic conductivities and a clay texture, although sandy Gley horizons are known to occur. The Gley soil form commonly occurs at the toe of hillslopes (or benches) where lateral water inputs (sub-surface) is dominant and the underlaying geology is characterised by a low hydraulic conductivity. The Gley horizon usually is second in diagnostic sequence in shallow profiles yet is known to be lower down in sequence and at greater depths (Soil Classification Working Group, 2018).

Figure 7-15 Soils identified within delineated watercourses. A) Orthic topsoil. B) Albic horizon

7.2.4.2 Hydrophytes

Vegetation plays a considerable role in identifying, classifying and accurately delineating wetlands (DWAF, 2005). During the site visit, various hydrophytic species were identified (including facultative species). Examples include *Juncus spp.* and *Typha capensis*.

Figure 7-16 Hydrophytic vegetation identified within delineated watercourses. A) Typha capensis B) Juncus spp.

7.2.5 General Functional Description

Unchanneled valley-bottoms are characterised by sediment deposition, a gentle gradient with streamflow generally being spread diffusely across the wetland, ultimately ensuring prolonged saturation levels and high levels of organic matter. The assimilation of toxicants, nitrates and phosphates are usually high for unchanneled valley-bottom wetlands, especially in cases where the valley is fed by sub-surface interflow from slopes. The shallow depths of surface water within this system adds to the degradation of toxic contaminants by means of sunlight penetration.

It is however important to note that the descriptions of the above-mentioned functions are merely typical expectations. All wetland systems are unique and therefore, the ecosystem services rated high for these systems on site might differ slightly to those expectations.

7.2.6 Ecological Functional Assessment

The ecosystem services provided by the wetland units identified on site were assessed and rated using the WET-EcoServices method (Kotze *et al.,* 2008). The summarised results for HGM 1 and 2 are shown in Table 7-6. The average ecosystem score for HGM 1 and 2 have been determined to have "Intermediate" and "Moderately Low" average ecosystem service scores. The main reason for HGM 1 being scored slightly higher scores than HGM 2 is attributed to the fact that HGM 1 is characterised by seasonally saturated zones where HGM 2 is predominantly characterised by temporary saturated conditions.

Seasonally saturated soils contain higher concentrations of anaerobic bacteria and is more likely to host hydrophytic vegetation, which both contribute to the assimilation of pollutants. A higher vegetation cover also slows down surface flows, which in turn limits erosion and flooding events.

Table 7-6 The ecosystem services being provided by the HGM units

Wetland Unit				HGM 1	HGM 2
Ecosystem Services Supplied by	**Indirect Benefits**	**Regulating and supporting**	Flood attenuation	**2.1**	**2.0**
			Streamflow regulation	**1.0**	**1.3**
			Sediment trapping	**2.3**	**2.1**

			Water Quality enhancement benefits	Phosphate assimilation	3.0	2.1
				Nitrate assimilation	3.4	2.4
				Toxicant assimilation	3.0	2.2
				Erosion control	2.8	2.3
			Carbon storage		1.7	1.3
	Direct Benefits	**Biodiversity maintenance**			0.8	0.9
		Provisioning benefits	Provisioning of water for human use		0.8	0.6
			Provisioning of harvestable resources		0.0	0.0
			Provisioning of cultivated foods		0.0	0.0
		Cultural benefits	Cultural heritage		0.0	0.0
			Tourism and recreation		0.6	0.3
			Education and research		0.3	0.3
Average Eco Services Score					1.4	1.2

7.2.7 The Ecological Health Assessment

The PES for the assessed HGM units is presented in Table 7-7. The overall PES score for both systems has been calculated to be "Seriously Modified". The hydrology score for HGM 1 is "Critically Modified" whereas that of HGM 2 is "Seriously Modified". The higher hydrological modification can be explained by the presence of a large TSF which significantly modifies the surface and sub-surface flows of the system. For similar reasons, the geomorphological modifications are slightly higher for HGM 1 than for HGM 2 due to the obstructive nature of the mentioned TSF as well as the mining areas (including open cast pit) to the southern portion of HGM 1.

As has been illustrated in Figure 7-17, the current surface flow direction is extremely disrupted, with the flow direction changing every 10 metres with no dominant flow direction being noticed. The reason for these varying flow directions can be explained by modifications to the topography, especially by means of the TSF. The expected flow direction prior to mining is south-west through a narrower wetland system.

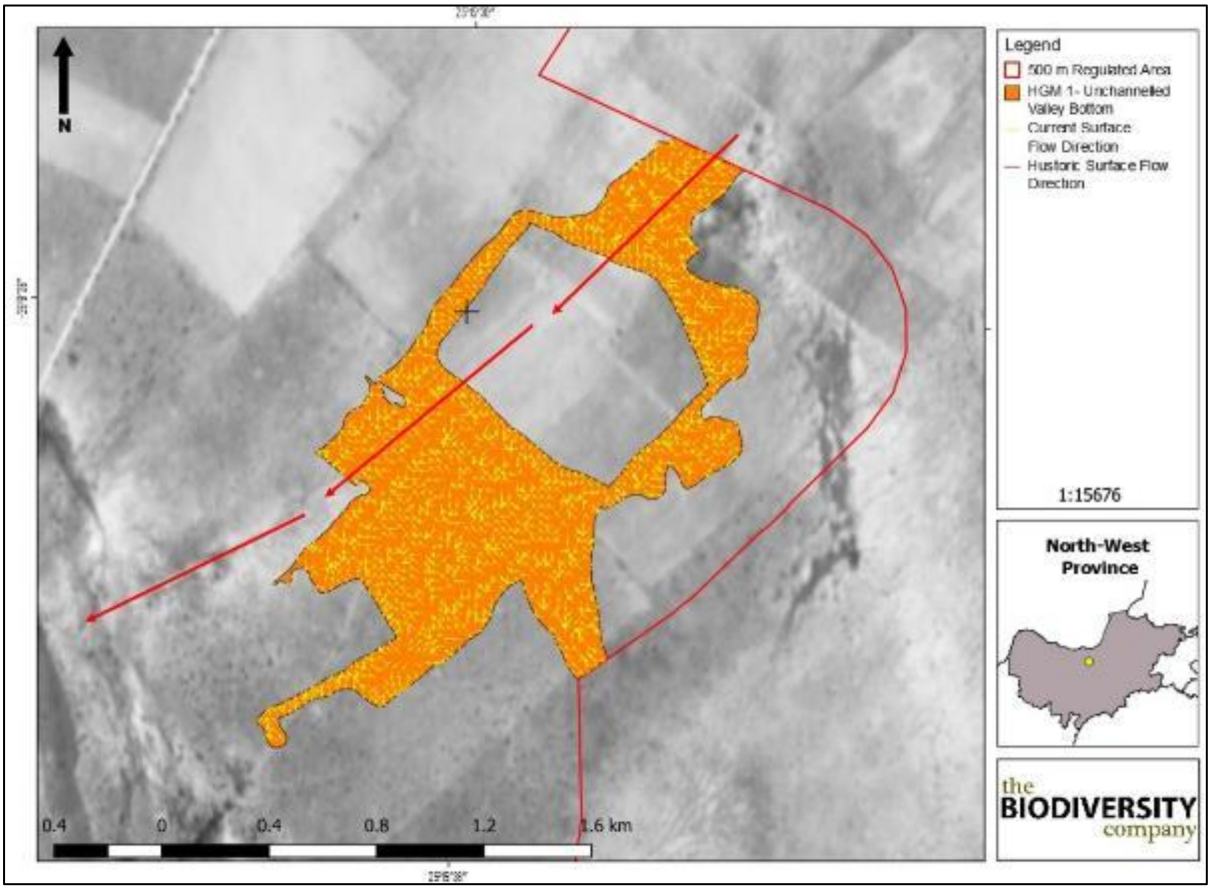

Figure 7-17 Current and historic flow directions for HGM 1

Table 7-7 Summary of the scores for the wetland PES

Wetland	Hydrology		Geomorphology		Vegetation	
	Rating	Score	Rating	Score	Rating	Score
HGM 1	F: Critically Modified	9.5	E: Seriously Modified	6.1	E: Seriously Modified	7.3
Overall PES Score	7.9		Overall PES Class		E: Seriously Modified	
HGM 2	E: Seriously Modified	6.5	C: Moderately Modified	3.6	F: Critically Modified	8.5
Overall PES Score	6.3		Overall PES Class		E: Seriously Modified	

The vegetation component of HGM 2 has been modified significantly more than HGM 1 due to the entire extent of the wetland being covered in crop fields. This phenomenon ultimately has resulted in natural vegetation being removed with the land cover being bare for long periods throughout the year after harvesting. Surface flows will therefore be more rapid, which ultimately will result in erosion and sediment loss.

7.2.8 The Ecological Importance & Sensitivity Assessment

The results of the ecological IS assessment are shown in Table 7-8. Various components pertaining to the protection status of a wetland is considered for the IS, including Strategic Water Source Areas (SWSA), the NFEPA wet veg protection status and the protection status of the wetland itself considering the NBA wetland data set. The IS for HGM 1 and 2 have been calculated to be “Moderate”, which combines all parameters listed in Table 7-8. The wetlands in question have been determined to have a “Low” importance and sensitivity.

Table 7-8 The IS results for the delineated HGM unit

HGM Type	Wet Veg		NBA Wetlands			SWSA (Y/N)	Calculated IS
	Type	Ecosystem Threat Status	Ecosystem Protection Level	Wetland Condition	Ecosystem Threat Status 2018		
HGM 1 and 2	Eastern Kalahari Bushveld Group 1	Least Threatened	Partially Protected	N/A	N/A	N	**Low**

7.3 Buffer Requirements

The "Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries" (Macfarlane *et al.,* 2014) was used to determine the appropriate buffer zone for the proposed activity. Four components were considered during the buffer calculations, namely the extension of the open cast pits, the construction of stockpiles, the construction of ancillary infrastructure as well as the construction of linear components (i.e. roads and pipelines). The findings from these calculations are illustrated in Table 7-9. It is worth noting that these buffer zones were assigned to the components rather than the wetlands to determine which of the buffer zones impede into the wetland zones (Figure 7-18). The only wetland system located within any of the proposed components' buffer zones is that of HGM 1. This wetland system will be affected by two components, namely linear components as well as the recommissioning of the TSF. Ultimately, these two components' impacts on HGM 1 will be focussed on during the impact assessment. In addition, the riparian zone will also be impacted upon by means of linear activities. These buffers are to be implemented from the edge of the wetland systems, with no development permitted within these buffers, unless authorised.

Table 7-9 Buffer calculations

	Open Cast Extension	Proposed and Recommissioning of Stockpiles	New Ancillary Infrastructure	New Linear Components
Buffer Size	106 m	38 m	22 m	15 m

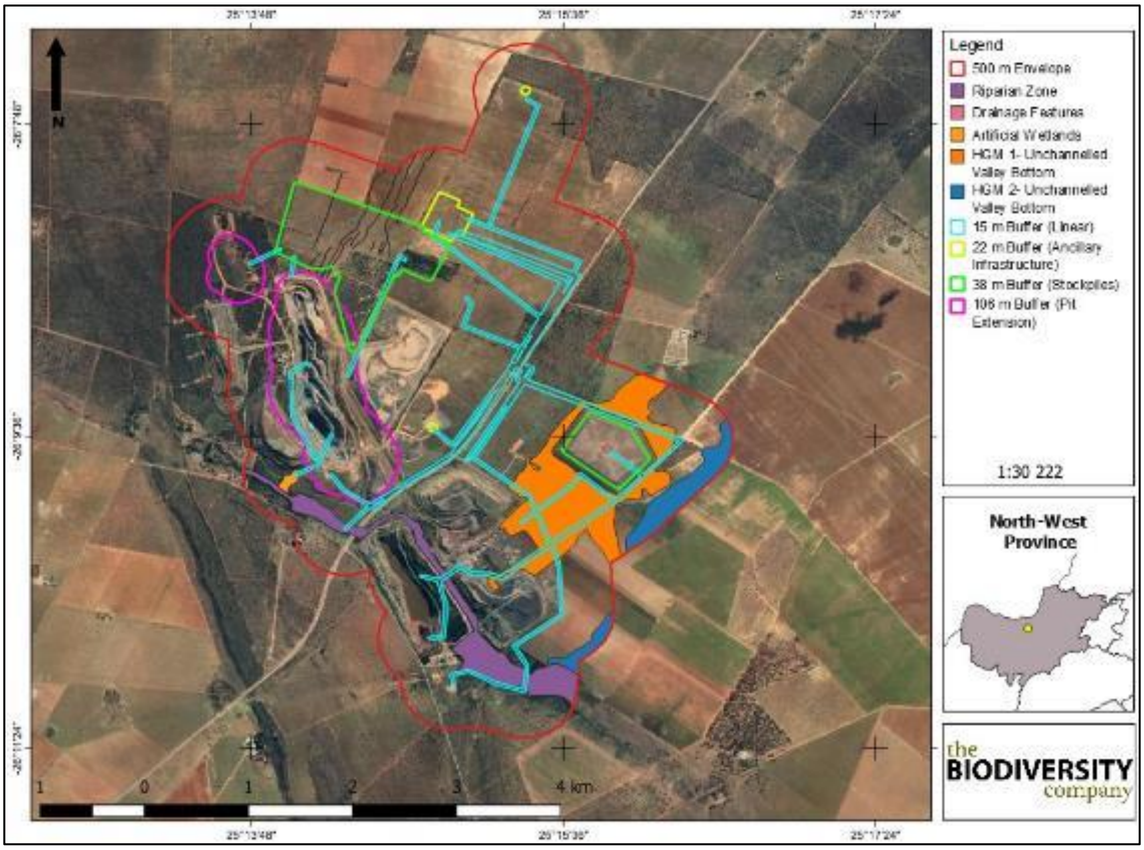

Figure 7-18 Various buffer zones associated with the proposed activities

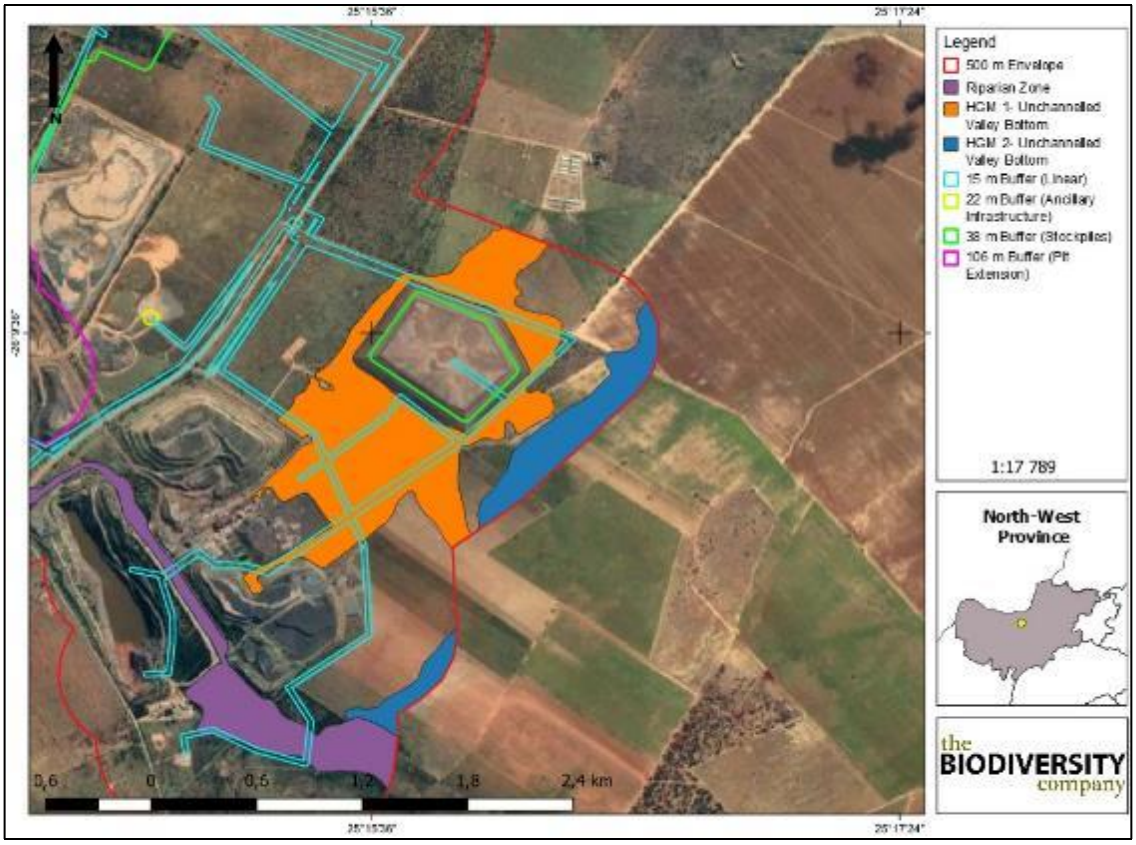

Figure 7-19 Wetland zone expected to be impacted upon by means of the linear activities as well as the recommissioning of the TSF

8 Water Resource Sensitivity

8.1 Approach

As part of the EIMS environmental mapping methodology, specialists are required to identify all features in terms of the specific field of expertise within the study area. This methodology includes the compilation of detailed shapefiles with specific attributes. Three main components form part of this methodology, namely;

- Feature layer;
- Overall sensitivity layer; and
- Legislative constraint layer.

All identified features will be rated according to the sensitivity of the feature as well as threats posed by proposed activities. These sensitivity rankings are described and illustrated in Table 8-1.

Table 8-1 Sensitivities relevant to the EIMS methodology

	Sensitivities				
	Least Concern	Low	Medium	High	No-Go
Broad Class Description	The inherent feature status and sensitivity is already degraded. The proposed development will not affect the current status and/or may result in a positive impact. These features would be the preferred alternative for the project or infrastructure placement.	The proposed development will have not had a significant effect on the inherent feature status and sensitivity.	The proposed development will negatively influence the current status of the feature.	The proposed development will negatively significantly influence the current status of the feature.	The proposed development cannot legally or practically take place.
Scoring	0	1	2	3	+99

8.2 Wetland Sensitivity

8.2.1 Feature Layer

Various delineated features make up the wetland features, which include artificial wetlands, the riparian zone, HGM 1 and HGM 2 as well as drainage features.

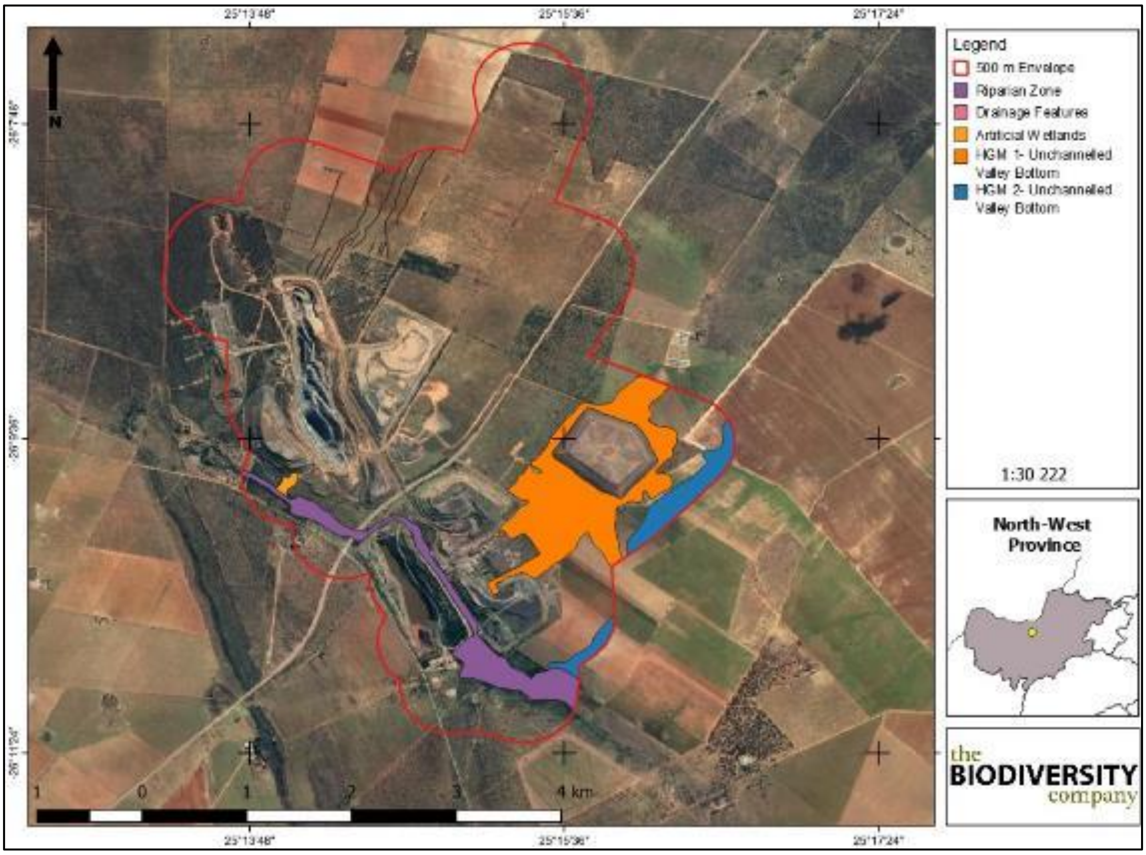

Figure 8-1 Feature layers within the mining boundaries

8.2.2 Overall Sensitivity

All features mentioned in Section 8.2.1- "Feature Layer" have been scored a sensitivity rating as per the EIMS methodology. HGM 1 and the riparian zone has been scored "Medium Sensitivity" due to the fact that linear components are proposed to cross and impede into these systems.

As for HGM 2, the drainage features and the artificial wetland, least concern sensitivity scores are applicable. Besides the fact that the latter two are deemed non-sensitive, no impacts are foreseen to these systems by means of any of the proposed components.

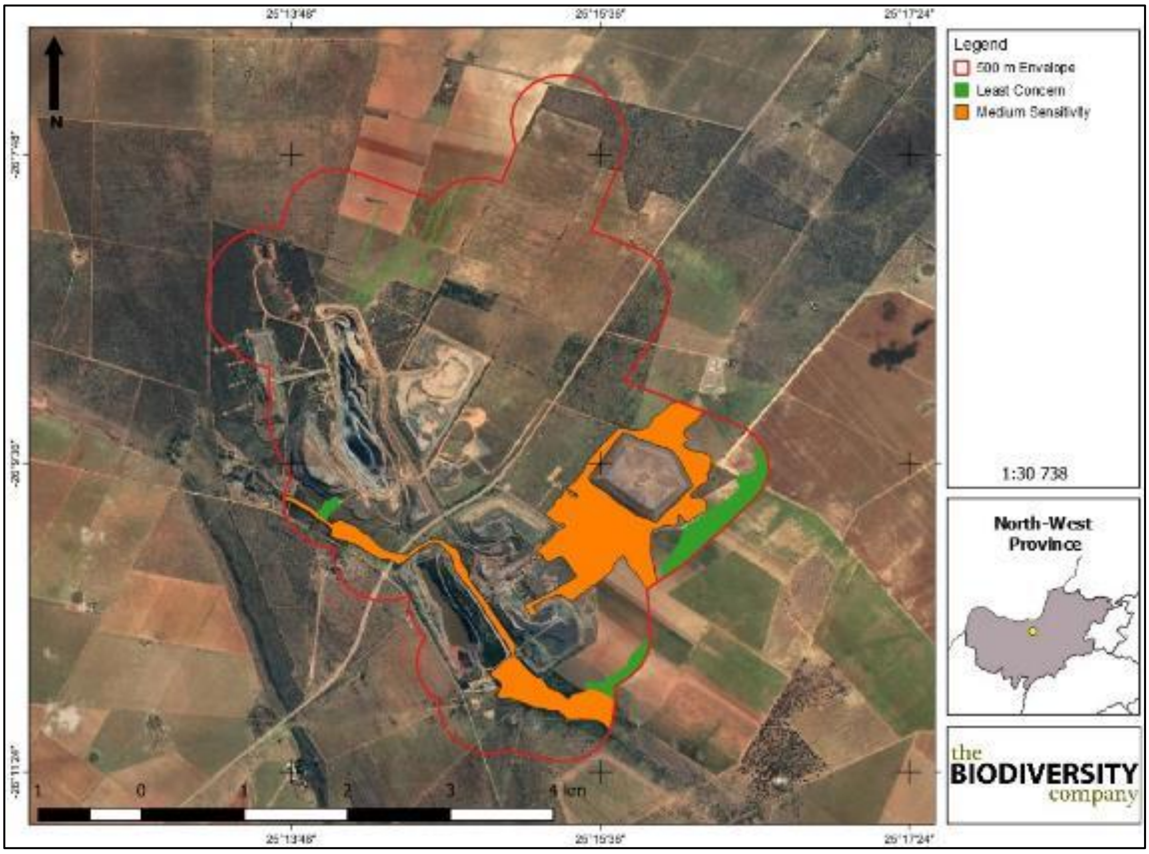

Figure 8-2 Overall sensitivity of identified features

8.2.3 Legislative Constraints

All areas within the identified wetlands' 500 m regulated area are subject to the National Water Act (NWA) Section 21 (C) and (I), as illustrated in Figure 8-3. A water use license or general authorisation (depending on the level of post-mitigation significance ratings) will have to be applied for linear activities impeding into these features as well as for the reclamation of the TSF.

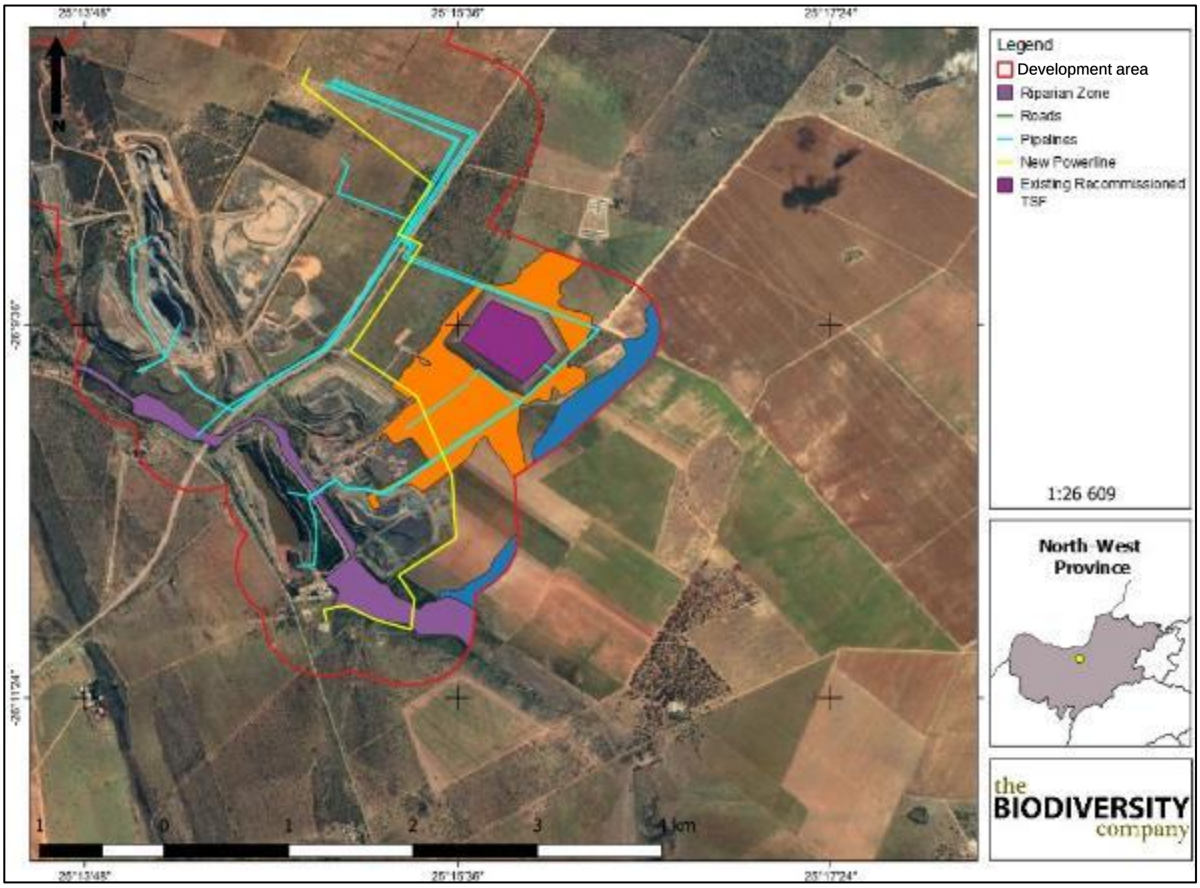

Figure 8-3 Legislative constraints relevant to identified features

9 Impact Assessment

This report considers the finding of the previously conducted scoping phase of the project which was verified and adjusted based on ground truthing which was completed during the September 2021 survey. As has been mentioned, the only components expected to impact upon the identified watercourses is that of linear activities (i.e. pipelines and powerlines).

Impacts were assessed in terms of the construction/operational, decommissioning/ rehabilitation and closure phases. Mitigation measures were only applied to impacts deemed relevant.

9.1 Impact Assessment Methodology

An impact assessment methodology was provided by EIMS to determine the environmental risk associated with various aspects related to the proposed expansion alternatives. This impact assessment takes the following components into consideration.

- The nature of the associated impact (positive or negative);
- The extent of the proposed activities;
- The duration of the proposed activities;
- The magnitude of the effects caused by the proposed activities;
- The reversibility of associated impacts; and
- The probability of relevant aspects affecting sensitive receptors.

Each one of the above-mentioned components are given a rating, which cumulatively provides the specialist with a pre-mitigation environmental risk rating. These components are then scored again taking into consideration mitigating factors. The cumulative impact and irreplaceable loss to sensitive receptors are then scored to ultimately indicate a "Priority Factor" score.

9.2 Freshwater Ecology Impact Assessment

The anticipated impacts are derived from the main activities associated with the expansion which include:

- New Processing Plant;
- New Powerline;
- New Explosives Magazine;
- Increasing the Pit Footprint;
- Pumping tailings material into the recommissioned TSF;
- Expansion of the Spanover Waste Rock Dump (WRD);
- A Series of new Roads;
- A Series of new Pipelines;

- New Trackless Mobile Machine (TMM) Workshop; and
- New Run of Mine (ROM) Pad.

The proposed project activities were determined to have two primary potential impacts to the associated freshwater ecology. The first was determined to be related to the conditions within the physical make-up of the considered water resources. This includes the substrates, banks, wetland and riparian vegetation and also the water column. These physical components of a watercourse determine the quality of the habitats. Therefore, modification of these physical components would result in a habitat quality impact. The second impact was determined to be related to the chemical properties of water. Considering aquatic biota and vegetation have requirements for habitat, as well as sensitivity to changes in water chemistry, a change to water quality is anticipated to have negative impacts.

Only two components will be regarded for this impact assessment, including the recommissioning of the TSF as well as linear activities (pipelines and powerlines). These components specifically impede into the riparian zone as well as HGM 1.

9.2.1 Unplanned Events

The planned activities will have anticipated impacts as discussed; however, unplanned events may occur on any project and may have potential impacts which will need management. Table 9-1 is a summary of the findings of an unplanned event assessment from an ecological perspective. Note, not all potential unplanned events may be captured herein, and this must therefore be managed throughout all phases according to recorded events.

Table 9-1 Summary of unplanned events for terrestrial biodiversity

Unplanned Event	Potential Impact	Mitigation
Hydrocarbon spills into the surrounding environment	Contamination of habitat as well as water resources associated with spillage.	A spill response kit must be available at all times. The incident must be reported on and if necessary a biodiversity specialist must investigate the extent of the impact and provide rehabilitation recommendations.
Fire	Uncontrolled/unmanaged fire that spreads to the surrounding natural grassland and wetlands	Appropriate/Adequate fire management plan need to be implemented.
Acid Mine Drainage	Severe water quality and in turn habitat degradation	Water treatment, post closure water monitoring and water level management.
TSF Failing or TSP Pipeline burst	Contamination of habitat as well as water resources.	Monitoring of TSF structure and follow legislative guidelines. Regular monitoring for leaks, cracks and faults in the pipeline

9.2.2 Planning Phase Impacts

The planning phase activities are considered a low risk as they typically involve desktop assessments and initial site inspections. This would include preparations and desktop work in support of waste management plans, environmental and social screening assessments, finalising drill sites and facilities and consultation with various contractors involved with a diversity of proposed project related activities going forward. It is assumed all existing servitudes will be used for access and existing plans are implemented, so based on this no impacts have been considered for the planning phase.

9.2.3 Construction Phase Impacts

In the construction phase topsoil will be stripped and vegetation will be cleared for all the aspects. This activity will alter the catchment drainage and subsequently result in erosion and sedimentation. The altered hydrology is likely to affect the structure of the water resources, resulting in erosion of the systems. Sedimentation of the resources will also contribute to impaired water and habitat quality.

9.2.3.1 TSF

The operational phase of the TSFs will include the construction of ancillary infrastructure, including pump stations, pipe connection components, ablution facilities etc. These components will typically be located in close proximity to the TSF, which potentially includes the construction thereof within HGM 1.

9.2.3.1.1 Mitigation Measures

See Section 10.

9.2.3.1.2 Cumulative Impacts

The cumulative impacts have been scored “Medium”, indicating that the potential incremental, interactive, sequential, and synergistic cumulative impacts. It is probable that the impact will result in spatial and temporal cumulative change. Various other mine related compounds are located within the 500 m regulated area, which will either have to be decommissioned or reclaimed, adding to this score.

9.2.3.1.3 Irreplaceable loss of Resources

The irreplaceable loss of resources has been scored “Medium”, where the impact may result in the irreplaceable loss of resources, but the value of these resources is limiting. The potential for an area being disturbed and degraded to such a degree that the functionality on that specific area is permanently lost does exist.

9.2.3.1.4 Impact on Alternatives Considered

No alternatives were provided due to the nature of the project as an expansion of an existing activity.

9.2.3.2 Construction of Pipelines and Powerlines

The construction of the pipelines and powerlines will include the clearance of servitudes as well as the placement of powerline pylons. This will disrupt the functionality of wetland areas for a brief period, after which the functionality of the wetland is expected to recover to some extent.

9.2.3.2.1 Mitigation Measures

Please see Section 10.

9.2.3.2.2 Cumulative Impacts

The cumulative impacts have been scored “Medium”, indicating that the potential incremental, interactive, sequential, and synergistic cumulative impacts. It is probable that the impact will result in spatial and temporal cumulative change. A wide network of pipelines and powerlines currently exist and are proposed for future expansions.

9.2.3.2.3 Irreplaceable loss of Resources

The irreplaceable loss of resources has been scored "Low" by considering the potential incremental, interactive, sequential and synergistic cumulative impacts. It is therefore unlikely that the impact will result in spatial and temporal cumulative changes.

9.2.3.2.4 Impact on Alternatives Considered

No alternatives were provided due to the nature of the project as an expansion of an existing activity.

9.2.4 Operational Phase Impacts

The operation phase for the proposed activities will result in the modification of the catchment drainage, which will alter riverine habitats through altered drainage. The presence of the processing and waste facilities will produce contaminated volumes of water that may present diffuse seepage/runoff into local riverine resources without mitigation. Stormwater management will therefore be crucial within the Kalgold operations to separate clean and dirty water from mixing as the potential for runoff to wash contaminants from the mine is high.

9.2.4.1 TSF

The operational phase of the TSFs will including the transportation of tailings material to the TSF from the processing plant. The potential impacts surrounding these activities typically include leaks from the TSF and/or pipelines and potential erosion/collapses of the TSF.

9.2.4.1.1 Mitigation Measures

See Section 10.

9.2.4.1.2 Cumulative Impacts

The cumulative impacts have been scored "Medium", indicating that the potential incremental, interactive, sequential, and synergistic cumulative impacts. It is probable that the impact will result in spatial and temporal cumulative change. Various other compounds are located within the development envelope, which will either have to be decommissioned or reclaimed, adding to this score.

9.2.4.1.3 Irreplaceable loss of Resources

The irreplaceable loss of resources has been scored "Medium", where the impact may result in the irreplaceable loss of resources, but the value of these resources is limiting. The potential for an area being disturbed and degraded to such a degree that the functionality on that specific area is permanently lost does exist.

9.2.4.1.4 Impact on Alternatives Considered

No alternatives were provided due to the nature of the project as an expansion of an existing activity.

9.2.4.2 Operation of Pipelines and Powerlines

The operational phase of the pipelines and powerlines will include infrastructure being maintained and monitored frequently, with no other expected impacts potentially threatening water resources.

9.2.4.2.1 Mitigation Measures

Please see Section 10.

9.2.4.2.2 Cumulative Impacts

The cumulative impacts have been scored "Medium", indicating that the potential incremental, interactive, sequential, and synergistic cumulative impacts. It is probable that the impact will result in spatial and temporal cumulative change. A wide network of pipelines and powerlines currently exist and are proposed for future expansions.

9.2.4.2.3 Irreplaceable loss of Resources

The irreplaceable loss of resources has been scored "Low" by considering the potential incremental, interactive, sequential and synergistic cumulative impacts. It is therefore unlikely that the impact will result in spatial and temporal cumulative changes.

9.2.4.2.4 Impact on Alternatives Considered

No alternatives were provided due to the nature of the project as an expansion of an existing activity.

9.2.5 Decommissioning and Rehab/Closure Phase Impacts

The decommissioning/closure phase for the proposed activities will result in similar impacts to the construction phase, in that infrastructure will be removed and the catchment area disturbed once again. It is however anticipated that the expanded TSF will remain *in situ* and that seepage and runoff from the expanded TSF is therefore likely to contribute to the overall salt loads in the catchment in the long term. The rehabilitation phase is expected to reduce the overall negative impact significance for selected aspects such as the removal and rehabilitation of roads, pipeline routes and powerline routes.

9.2.5.1 TSF

The decommissioning phase of the TSFs will including removal of ancillary infrastructure that contributed to the success of the operational phase.

9.2.5.1.1 Mitigation Measures

See Section 10.

9.2.5.1.2 Cumulative Impacts

The cumulative impacts have been scored "Medium", indicating that the potential incremental, interactive, sequential, and synergistic cumulative impacts. It is probable that the impact will result in spatial and temporal cumulative change. Various other mine related compounds are located within the development area, which will either have to be decommissioned or reclaimed, adding to this score.

9.2.5.1.3 Irreplaceable loss of Resources

The irreplaceable loss of resources has been scored “Medium”, where the impact may result in the irreplaceable loss of resources, but the value of these resources is limiting. The potential for an area being disturbed and degraded to such a degree that the functionality on that specific area is permanently lost does exist.

9.2.5.1.4 Impact on Alternatives Considered

No alternatives were provided due to the nature of the project as an expansion of an existing activity.

9.2.5.2 Decommissioning of Pipelines and Powerlines

The decommissioning phase of the pipelines and powerlines will include infrastructure being removed from their current locations. This includes the use of heavy machinery.

9.2.5.2.1 Mitigation Measures

Please see Section 10.

9.2.5.2.2 Cumulative Impacts

The cumulative impacts have been scored “Medium”, indicating that the potential incremental, interactive, sequential, and synergistic cumulative impacts. It is probable that the impact will result in spatial and temporal cumulative change. A wide network of pipelines and powerlines currently exist and are proposed for future expansions.

9.2.5.2.3 Irreplaceable loss of Resources

The irreplaceable loss of resources has been scored “Low” by considering the potential incremental, interactive, sequential and synergistic cumulative impacts. It is therefore unlikely that the impact will result in spatial and temporal cumulative changes.

9.2.5.2.4 Impact on Alternatives Considered

No alternatives were provided due to the nature of the project as an expansion of an existing activity.

9.3 Assessment of Significance

Table 9-2 shows the significance of potential impacts associated with the proposed expansion project (specifically focussing on the continuation of the TSF and the operation of linear infrastructure) before and after the implementation of mitigation measures as well as cumulative and irreplaceable loss. The final results indicate “Low” post-mitigation significance ratings for the proposed TSF as well as the linear activities (pipelines and power lines). The remainder of the components that have not been assessed during the impact assessment are all expected to have no risks towards watercourses. Regardless, various mitigation measures will be prescribed to ensure that no impacts originate from these components.

Table 9-2 Assessment of significance of potential impacts on the watercourses associated with the project

Impact	Phase	Pre-mitigation ER	Post-mitigation ER	Confidence	Cumulative Impact	Irreplaceable loss	Priority Factor	Final score
Continuation of TSF	Construction	-6,75	-3,5	Moderate	2	2	1,50	-5,25
Construction of Pipelines and Powerlines	Construction	-4	-3	Moderate	2	1	1,33	-4,00
Continuation of TSF	Operation	-8,25	-5	Moderate	2	2	1,50	-7,50
Operation of Pipelines and Powerlines	Operation	-5	-4,5	Moderate	2	1	1,33	-6,00
Reclamation of TSF	Decommissioning	-6,75	-3,5	Moderate	2	2	1,50	-5,25
Reclamation of Pipelines and Powerlines	Decommissioning	-4	-3	Moderate	2	1	1,33	-4,00

10 Specialist Management Plan

Table 10-1 presents the recommended mitigation measures and the respective timeframes, targets and performance indicators. The mitigation measures within this section have been taken into consideration during the impact assessment in cases where the post-mitigation environmental risk is lower than that of the pre-mitigation environmental risk.

Table 10-1 Mitigation measures including requirements for timeframes, roles and responsibilities for the freshwater study.

Impact Management Actions	Implementation		Monitoring	
	Phase	Responsible Party	Aspect	Frequency
Effective stormwater management which includes and controls seepage and runoff control from the expanded operational TSF area	Construction Phase but applied as necessary through Life of Project	Contractor and Environmental Officer	Infrastructure and crossings	Ongoing
Implementation of clean and dirty water separation as effective pollution control using a diversion trench and berm systems which diverts clean stormwater around pollution sources and convey and contain dirty water to central pollution control impoundments effectively controlling runoff. The use of barrier systems, including synthetic, clay and geological liners to minimize contaminated seepage and runoff is encouraged.	Construction Phase but applied as necessary through Life of Project	Contractor and Environmental Officer	Infrastructure and crossings	Ongoing
Erosion and sedimentation controls such as energy dissipation and silt screens where feasible. The focus must be placed on locations where stormwater enters the watercourse from disturbed areas.	Construction Phase but applied as necessary through Life of Project	Contractor and Environmental Officer	Infrastructure and crossings	Ongoing
The crossing points should be stabilized to reduce the resulting erosion and downstream sedimentation. Access crossing points must be prioritized and upgraded.	Planning and Construction Phase	Contractor and Environmental Officer	Crossings	During Phase
Structures must not be damaged by floods smaller than those which may occur on average once in every 50 years	Planning and Construction Phase	Contractor and Environmental Officer	Crossings	Ongoing
The indiscriminate use of heavy vehicles and machinery within the water resource areas will result in the compaction of soils and vegetation and must be controlled	Construction and Decommissioning/closure Phase	Contractor and Environmental Officer	Vehicles and machinery	During Phase
Erosion prevention mechanisms such as gabions must be employed to ensure the sustainability of all structures to prevent instream sedimentation where feasible	Construction Phase but applied as necessary through Life of Project	Contractor and Environmental Officer	Crossings	Ongoing
The planting of indigenous vegetation around pollution control impoundments and structures should be completed as this has been shown to be effective in erosion and nutrient control	Operational and Decommissioning, and Rehabilitation Phase	Environmental Officer	Infrastructure and crossings	Ongoing
The continued removal of alien invasive flora species	Life of Project	Environmental Officer	Project area	Ongoing
The continued implementation of the derived buffer zones and avoidances. Prioritize the use of existing routes and servitudes	Life of Project	Environmental Officer	Project area	Indefinitely
The feasibility of passive or active water treatment and containment for seepage and runoff emanating from the TSF and decant areas must be investigated	Rehabilitation Phase	Contractor and Environmental Officer	Decant & run-off areas	Indefinitely

11 Conclusion

The water resource findings identified two wetland systems (unchanneled valley bottom wetlands), one riparian zone, an artificial wetland as well as drainage features. The wetland baseline findings indicate “Seriously Modified” overall present ecological states with an importance and sensitivity rating of “Low”.

The average ecosystem service score for HGM 1 and 2 have been calculated to be “Intermediate” and “Moderately Low” respectively. The buffer requirements differ depending an the associated activities. The buffer zone applicable to the extension of the open cast pit is calculated at 106 m, the stockpiles at 38 m, the ancillary infrastructure at 22 m and the linear infrastructure 1t 15 m. These buffers are demarcated from the edge of the wetland, and may not be encroached upon without authorisation.

The Morokwa River and associated tributary was dry during the September 2021 survey. Satellite imagery indicated, the system is dry all year long, with no evidence of flow. As a result, the only assessment conducted was water quality and IHIA to assess habitat availability. *In-situ* and *ex-situ* water analysis indicate modification to the system, with nutrient and compound salts observed in elevated amounts - with the Norman Dam eutrophic in nature. The IHIA indicates that instream habitat is moderately modified (class C) while the riparian habitat is largely modified (class D). The riparian area is poorly developed with vegetation indistinguishable from terrestrial vegetation. This results from lack of surface flow, the river diversion and instream dams.

11.1 Impact Statement

The approach indicates “Low” post-mitigation significance ratings for the proposed continued use of the TSF as well as the linear activities (pipelines and power lines). The remainder of the components that have not been assessed during the impact assessment are all expected to have no risks towards watercourses. Regardless, various mitigation measures will be prescribed to ensure that no impacts originate from these components.

12 References

Barbour, M.T., Gerritsen, J. & White, J.S. 1996. Development of a stream condition index (SCI) for Florida. Prepared for Florida Department of Environmental Protection: Tallahassee, Florida.

BGIS (Biodiversity GIS). (2018). http://bgis.sanbi.org/ (Accessed: October 2020).

Dallas HF. 2007. River Health Programme: South African Scoring System (SASS) Data Interpretation Guidelines. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Institute of Natural Resources.

DEA. (2015). National land cover data for SA. https://egis.environment.gov.za/national_land_cover_data_sa (Accessed: June 2020).

Department of Water Affairs and Forestry (DWAF). 1996. South African Water Quality Guidelines. Volume 7: Aquatic Ecosystems.

Department of Environmental Affairs. 2013. Mining and biodiversity guideline- Mainstreaming biodiversity into the mining sector.

Department of Water Affairs and Forestry (DWAF) 2005. Final draft: A practical field procedure for identification and delineation of wetlands and Riparian areas.

Department of Water and Sanitation (DWS). 2021. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Draft. Compiled by RQS-RDM.

Dickens CWS, Graham PM.2002. The South African Scoring System (SASS), Version 5, Rapid bioassessment method for rivers. *African Journal of Aquatic Science*. 27**:** 1–10.

EIMS, 2018. Background Information Document. Kalgold Expansion Project. 1260_BID_181023_JP.

Elmore, W. and Beschta, R.L., 1987. Riparian areas: perceptions in management. Rangelands Archives, 9(6), pp.260-265.

Ezemvelo, K.Z.N., Wildlife IEM 2013 Guideline: Biodiversity Impact Assessment in KwaZulu-Natal.

Gerber, A. & Gabriel, M.J.M. 2002. Aquatic Invertebrates of South African Rivers Field Guide. Institute for Water Quality Studies. Department of Water Affairs and Forestry. 150pp

International Union for Conservation of Nature and Natural Resources (IUCN). (2021). Red list of threatened species - 2021.2. www.iucnredlist.org. (Accessed in September 2021)

Kleynhans CJ, Louw MD. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Resource Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08.

Kleynhans CJ. 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo System, South Africa) Journal of Aquatic Ecosystem Health 5:41-54.

Kotze DC, Marneweck GC, Batchelor AL, Lindley DC, Collins, NB. 2008. A Technique for rapidly assessing ecosystem services supplied by wetlands. Mondi Wetland Project.

Land Type Survey Staff. (1972 - 2006). Land Types of South Africa: Digital Map (1:250 000 Scale) and Soil Inventory Databases. Pretoria: ARC-Institute for Soil, Climate, and Water.

Macfarlane, D.M., Kotze, D.C., Ellery, W.N., Walters, D., Koopman, V., Goodman, P. Goge, C. 2008. WET-Health, A technique for rapidly assessing wetland health.

Macfarlane, D.M. & Bredin, I.P. 2017. Buffer Zone Guidelines for Rivers, Wetlands and Estuaries Buffer Zone Guidelines for Rivers, Wetlands and Estuaries. WRC Report No TT 715/1/17 Water Research Commission, Pretoria

Macfarlane, D.M., Dickens, J. & Von Hase, F. 2009. Development of a methodology to determine the appropriate buffer zone width and type for developments associated with wetlands, watercourses and estuaries.

Mucina, L. and Rutherford, M.C. (Eds.) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelizia 19. South African National Biodiversity Institute, Pretoria South African.

National Water Act (NWA). 2016. Act 36 of 1998. New Nine (9) Water Management Areas of South Africa. National Gazettes, No. 40279 of 16 September 2016.

National Environmental Management Act. 1998. National Environmental Management Act (act no. 107 of 1998)- Environmental management framework regulations.

Nel JL, Murray KM, Maherry AM, Petersen CP, Roux DJ, Driver A, Hill L, Van Deventer H, Funke N, Swartz ER, Smith-Adao LB, Mbona N, Downsborough L and Nienaber S. 2011. Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

Ollis DJ, Snaddon CD, Job NM, and Mbona N. 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. SANBI Biodiversity Series 22. South African Biodiversity Institute, Pretoria.

Republic of South Africa (RSA). 2020. Screening Report for an Environmental Authorization or for a Part Two Amendment of an Environmental Authorisation as Required by the 2014 EIA Regulations – Proposed Site Environmental Sensitivity – Kalgold Expansion (Accessed 01/10/2020 11:43:15)

Rountree MW, Malan H and Weston B (editors). 2012. Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0). Joint Department of Water Affairs/Water Research Commission Study. Report No XXXXXXXXX. Water Research Commission, Pretoria.

Skelton, P.H. (2001). A complete guide to the freshwater fishes of southern Africa. Struik Publishers, South Africa.

Soil Classification Working Group. (1991). Soil Classification A Taxonomic system for South Africa. Pretoria: The Department of Agricultural Development.

Soil Classification Working Group. (2018). Soil Classification A Taxonomic system for South Africa. Pretoria: The Department of Agricultural Development.

South African National Biodiversity Institute (SANBI). 2009. Further Development of a Proposed National Wetland Classification System for South Africa. Primary Project Report. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).

Tate RB, Husted A. 2015. Aquatic macroinvertebrate responses to pollution of the Boesmanspruit river system above Carolina, South Africa. African Journal of Aquatic Science. 1-11.

Thirion C. 2007. Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 332/08.

Van Deventer, H., Smith-Adao, L., Mbona, N., Petersen, C., Skowno, A., Collins, N.B., Grenfell, M., Job, N., Lötter, M., Ollis, D., Scherman, P., Sieben, E. & Snaddon, K. 2018. South African National Biodiversity Assessment 2018: Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 October 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa.

13 Appendices

Appendix A Specialist declarations

DECLARATION

I, Michael Ryan, 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 Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, 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; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.

MRyan

Michael Ryan

Riverine Ecologist (Cand. Sci. Nat. 125128)

The Biodiversity Company

October 2021

DECLARATION

I, Ivan Baker, 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 Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, 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; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.

Ivan Baker

Wetland Specialist (Cand. Sci. Nat. 119315)

The Biodiversity Company

October 2021

Michael Ryan

B.Sc Honours (Geography)

Cell: +2716076548

Email: michael@thebiodiversitycompany.com

Identity Number: 9412215103084

Date of birth: 21 December 1994

Profile Summary

Have experience in Environmental Consulting providing Aquatic Ecology expertise to BA and EIA applications for a wide range of projects spanning southern Africa. To the same note have provided monitoring services for mining and industry in accordance with licencing.

I have had the pleasure of conducting assessments on a plethora of projects which range from mining, industry, infrastructure and river health programs.

Areas of Interest

Mining

Renewable Energy.

Conservation Value

Water Resource Management

Aquatic Ecology

Macroinvertebrates

Hydrology

Flood line determination

Key Experience

- Aquatic and wetland fieldwork collection.
- Water resource baseline, monitoring and impact assessments
- Aquatic ecology studies in accordance to local and international standards
- River Health Investigation

Countries worked in

Lesotho

South Africa

Swaziland

Zimbabwe

Nationality

South African

Languages

English – Proficient

Afrikaans – Proficient

Qualifications

- BSc Honours Geography
- BSc Geography, Geology and Advanced Earth Science
- SASS5– Department of Water Affairs and Forestry for the River Health Programme
- Cand. Sci. Nat (125128)

SELECTED PROJECT EXPERIENCE

Project Name: Aquatic biomonitoring of the Limpopo River for the Boikarabelo Coal Mine, in Limpopo

Province.

Client: Ledjadja Coal.

Personal position / role on project: Fieldwork intern

Location: South Africa (Limpopo) – 2017 to present

Main project features: To collect adequate in situ water quality, invertebrate, Fish and riparian data to allow for analysis and report writing.

Project Name: An aquatic specialist baseline and impact assessment for the N2 road upgrade, in

KwaZulu Natal Province.

Client: EnviroPro.

Personal position / role on project: Fieldwork intern.

Location: South Africa (KwaZulu Natal) - 2018

Main project features: To collect adequate in situ water quality, invertebrate, Fish and riparian data to allow for analysis and report writing.

Project Name: Aquatic biomonitoring of the Kloof Mining Operation, Gauteng, South Africa.

Client: Sibanye Stillwater

Personal position / role on project: Fieldwork intern

Location: Gauteng, South Africa– 2018 to present

Main project features: To collect adequate in situ water quality, invertebrate, Fish and riparian data to allow for analysis and report writing.

Project Name: Environmental and Social Impact Assessment and Resettlement Action Plan: Lesotho Lowlands Bulk Water Supply Scheme Zone.

Client: WSP

Personal position / role on project: Fieldwork intern

Location: Lesotho - 2019

Main project features: To collect adequate in situ water quality, invertebrate, Fish and riparian data to allow for analysis and report writing.

Project Name: The Environmental and Social Impact Assessment (ESIA) the proposed Nondvo Dam

Client: WSP

Personal position / role on project: Fieldwork intern

Location: Swaziland 2019

Main project features: To collect adequate in situ water quality, invertebrate, Fish and riparian data to allow for analysis and report writing.

Project Name: Water Resource Assessment for the Mahlokohloko Road Upgrade, Sungulwane, KwaZulu-Natal

Client: Enviropro

Personal position / role on project: Junior Aquatic Ecology Specialist and Wetland fieldwork.

Location: KwaZulu-Natal, South Africa

Main project features: The baseline and impact assessment for the proposed road upgrade as well as wetland assessment and data collection for delineations.

Project Name: Flood line, SWMP and hydrology Report for the Caledon River

Client: EnviroMatrix

Personal position / role on project: Junior Hydrologist.

Location: Caledonspoort Border post between South Africa and Lesotho 2019

Main project features: To model the 1:50 and 1:100 year floods for an abstraction point on the Caledon river as well as calculate water balances and create a stormwater management plan.

Project Name: Ergo Pipeline Aquatic Biomonitoring 2018-2019

Client: Hydroscience

Personal position / role on project: Aquatic Ecology Specialist

Location: Elsburgspruit River reach, Ekurhuleni Metropolitan Municipality, Gauteng 2019

Main project features: To conduct annual biomonitoring of the aquatic ecosystems associated with various pipelines used by Ergo Gold Mining Operations (Ergo) as per the conditions of a Water Use License (WUL).

OVERVIEW

An overview of the specialist technical expertise includes the following:

- Aquatic ecological state and functional assessments of waterbodies.
- Risk assessments to waterbodies by activities
- Monitoring plans for rivers and other wetland systems.
- Flood line determination.
- Hydrology studies.

EMPLOYMENT EXPERIENCE

Name of Organization, City, Country: The Biodiversity Company, Johannesburg, South Africa
Month, Year: July 2019 to Present
Position: Junior Aquatic Ecologist

- Implementation and planning of aquatic related studies
- Technical contributions for the monitoring, mitigation and identification of impacts to water resources associated with industrial and infrastructural developments
- Establishment and identification of baseline ecological and physical structures (surveys)

Name of Organization, City, Country: The Biodiversity Company, Johannesburg, South Africa
Month, Year: November 2017 to June 2019
Position: Fieldwork Intern

- Appropriate onsite data for both aquatic ecology reports as well as wetland delineations.
- This included water sample, soil sample and invertebrate and fish collection.

Ivan Baker

M.Sc Environmental Science and Hydropedology (*Cand Sci Nat*)

Cell: +27 79 898 4056

Email: ivan@thebiodiversitycompany.com

Identity Number: 9401105251087

Date of birth: 10 January 1994

Profile Summary

Working experience throughout Southern Africa

Working experience in West-Africa

Specialist experience with mining, construction and agriculture.

Specialist expertise include hydropedology, pedology, land contamination, agricultural potential, land rehabilitation, rehabilitation management and wetlands resources.

Experience hydropedological modelling (HYDRUS model)

Areas of Interest

Mining, Oil & Gas, Renewable Energy & Bulk Services Infrastructure Development, Farming, Land contamination, Sustainability and Conservation.

Key Experience

- Environmental Impact Assessments (EIA)
- Environmental Management Programmes (EMP)
- Wetland delineations and ecological assessments
- Rehabilitation Plans and Monitoring
- Soil-and rock classification
- Level 1, 2 and 3 hydropedology assessments
- Agriculture potential assessments
- Land contamination assessments
- Modulation of surface- and subsurface flows (HYDRUS model)

Country Experience

South Africa	Mozambique
Swaziland	Zimbabwe
Guinea	Zambia

Nationality

South African

Languages

English – Proficient

Afrikaans – Proficient

Qualifications

- MSc (North-West University of Potchefstroom) – Hydropedology
- BSc Honours (North-West University of Potchefstroom) – Environmental geology-Pedology and rehabilitation
- BSc Environmental sciences
- Cand Sci Nat (Pr Sci Nat Pending)
- Certificate of Competence: Tools for Wetland Assessments

SELECTED PROJECT EXPERIENCE

Project Name: Environmental impact assessment for the construction of Road DR08606 leading to Mlamli Hospital, Sterkspruit

Personal position / role on project: Wetland ecologist

Location: Sterkspruit, Eastern Cape Province, South Africa

Main project features: To conduct a wetland assessment, as a component of the environmental authorisation process and Water Use Licence Application (WULA) for the construction of Road DR08606 leading to Mlamli Hospital

Project Name: Biodiversity Baseline & Impact Assessment Report for the proposed Nondvo Dam Project

Personal position / role on project: Wetland ecologist

Location: Mbabane, Swaziland

Main project features: To conduct various assessments according to IFC standards in regard to delineation of wetlands and assessing ecosystem services.

Project Name: Agricultural Potential Assessment - Proposed Kalabasfontein Coal Mining Project Extension

Personal position / role on project: Project Manager and Soil Specialist.

Location: Bethal, Mpumalanga, South Africa

Main project features: To conduct a soil assessment to identify any sensitive resources that might be affected by the proposed mining activities and associated infrastructure as part of an environmental impact assessment.

Project Name: Soil assessment for the closure of the St Helena Shaft, Harmony

Personal position / role on project: Soil specialist

Location: Welkom, Free State, South Africa

Main project features: To conduct a thorough soil and fertility assessment to recommend relevant mitigation and rehabilitation measures to finalise closure at the relevant mine

Project Name: Wetland Functionality Assessment for the Environmental, Health and Socio-Economic Baseline Studies for Block 2 at Siguiri Gold Mine

Personal position / role on project: Wetland ecologist

Location: Siguiri, Guinea, West-Africa

Main project features: To conduct various assessments according to IUCN standards in regard to delineation of wetlands and assessing ecosystem services.

Project Name: Level 3 Hydropedological Assessment for the Sara Buffels Mining Project

Personal position / role on project: Hydropedologist

Location: Ermelo, Mpumalanga, South-Africa

Main project features: To conduct various assessments to determine the hillslope hydrology and to acquire information relevant to the vadose zone's hydraulic properties to quantify sub-surface flows by means of modelling.

Project Name: Level 3 Hydropedological Assessment for the Buffalo Coal Mining Project

Personal position / role on project: Hydropedologist

Location: Dundee, KwaZulu-Natal, South-Africa

Main project features: To conduct various assessments to determine the hillslope hydrology and to acquire information relevant to the vadose zone's hydraulic properties to quantify sub-surface flows by means of modelling

Project Name: Biodiversity Baseline & Impact Assessment for the proposed Tetereane 15MW Solar PV Plant

Personal position / role on project: Ecosystem Services Specialist

Location: Cuamba, Mozambique, Southern-Africa

Main project features: To conduct various assessments according to IUCN standards in regard to ecosystem services

Project Name: Land contamination assessment for the proposed Fleurhof Development

Personal position / role on project: Soil Specialist

Location: Fleurhof, South Africa

Main project features: To conduct assessments relevant to the determination of land contamination, including recommendations, mitigations and risk assessments.

OVERVIEW

An overview of the specialist technical expertise include the following:

- Ecological wetland assessment studies, including the integrity (health) and functioning of the wetland systems.
- Wetland offset strategy designs.
- Wetland rehabilitation plans.
- Monitoring plans for wetland systems.
- Soil classification and agricultural assessments.
- Stripping and stockpiling guidelines.
- Soil rehabilitation plans.
- Soil and stockpile monitoring plans.
- Hydropedological assessments.

TRAINING

Some of the more pertinent training undergone includes the following:

- Tools for a Wetland Assessment (Certificate of Competence) – Rhodes University 2018; and
- Workshop on digital soil mapping.

EMPLOYMENT EXPERIENCE

Internship at SRK consulting (January 2017-August 2017)

- **Field assistant** for SRK consulting during 2017 included the sampling of surface and groundwater as well as on site tests, the accumulation of various different data sets from field loggers, presenting and arranging the relevant data and ultimately using it for my own personal post-graduate studies.

Internship at The Biodiversity Company (August 2017-December 2017)

Employed as an intern (wetland and soil scientist) during the last few months of 2017. During this period, I was part of a variety of soil- and wetland projects, both as report writer and/or field assistant.

CURRENT EMPLOYMENT: The Biodiversity Company (January 2018 – Present)

- **Scientific report writing** to ensure that the relevant standards and requirements have been attained, namely local country legislation, as well as WB, EP and IFC requirements.

ACADEMIC QUALIFICATIONS

North-West University of Potchefstroom: MAGISTER SCIENTIAE (MSc) - Hydropedology:

Title: *Characterisation of vadose zone processes in a tailings facility*

North-West University of Potchefstroom (2016): BACCALAUREUS SCIENTIAE HONORIBUS (Hons) – Environmental Geology- Pedology and rehabilitation

North-West University of Potchefstroom (2015): BACCALAUREUS SCIENTIAE IN NATURAL AND ENVIRONMENTAL SCIENCES. Majors: Geology and Geography