Aquatic ecosystem impact assessment for various activities for the 2Seam Coal mining operations
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DECLARATION OF INDEPENDENCE

I, **Bertus Fourie**, declare that -

- I am subcontracted as specialist consultant by Limnology[1] for the project,
- I am a SACNASP registered Professional Natural Scientist registered in the field of Ecology and Aquatic Sciences,
- 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 National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity; I will comply with the Act, regulations, and all other applicable legislation.
- I will consider, to the extent possible, the matters listed in Regulation 8.
- 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 realize that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Bertus Fourie (Pr. Sci.Nat)

Limnologist

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1. Introduction

Limnology PTY LTD was appointed for the aquatic ecosystems condition and impact ratings for the proposed diversion of the Olifants River, new processing plant and run of mine stockpile, tailings facility, contractor yard and the two pollution control dams for the 2Seam Coal mine, Mpumalanga.

1.1. Aquatic ecosystem rationale

An aquatic ecosystem is defined as "an ecosystem that is permanently or periodically inundated by flowing or standing water or which has soils that are permanently or periodically saturated within 0.5 m of the soil surface" (Ollis *et al.* 2013). This term is further defined by the definition of a watercourse. In the National Water Act, 1998 (Act No. 36 of 1998) a watercourse is defined as:

(a) A river or spring.

(b) A natural channel in which water flows regularly or intermittently.

(c) A wetland, lake, or dam into which, or from which, water flows; and

(d) 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.

Different inland (freshwater) watercourses occur in South Africa and are defined by their topographical location, water source, hydroperiod, soils, vegetation, and functional units (Ollis, *et al.*, 2013). The following illustration presents the types and typical locations of different inland aquatic systems found in South Africa (Figure 1).

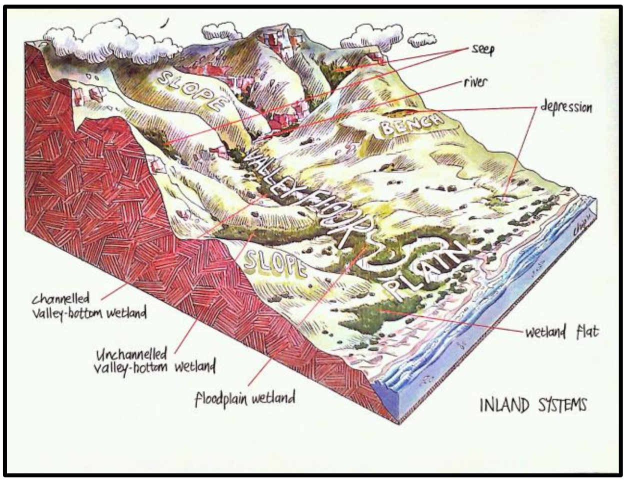

FIGURE 1: THE TYPES AND LOCATION OF INLAND AQUATIC ECOSYSTEMS (OLLIS, *ET AL*., 2013)

This definition of a watercourse is important especially if an area of increased hydrological movement is found but cannot be classified as either a wetland or riparian area. Important to note is that according to the National Water Act, 1998 (Act No. 36 of 1998), wetlands are defined as: *"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."*

It is very important that this definition is applied to both natural and manmade wetlands. Wetlands are very important in South Africa. Almost 50% of wetlands have been lost in South Africa and the conservation of the remaining wetlands is very important (WRC 2011) Wetlands provide many services to the ecosystem they are in (Kotze, *et al*. 2007). One of the most important services provided by wetlands is that of the impeding and holding back of floodwater to be released more constantly as well as slow water release through dry periods (Collins, 2005). Other very important functions that wetlands provide are as a source of habitat to many different species of fauna and flora. Wetlands also lead to an increase in the overall biodiversity of the area and ecological functioning (Collins, 2005).

Wetland conditions are formed when the prolonged saturation of water in the soils create different niche conditions for various fauna and flora. The source of water feeding into a wetland is very important, as it is an indication of the type and in many cases can provide an indication of the condition of the wetland.

As South Africa is a signatory of the Ramsar Convention for the conservation of important wetlands, we are committed to the conservation of all our wetlands. The Convention on Wetlands came into force for South Africa on 21 December 1975. South Africa presently has 21 sites designated as Wetlands of International Importance, with a surface area of 554,136 hectares (www.ramsar.org).

Although the term wetland describes the main *functions* provided by the wetland, there are many different hydrogeomorphic *types* of wetlands in South Africa.

The word "riparian" is drawn from the Latin word "riparious" meaning "bank" (of the stream) and simply refers to land adjacent to a body of water or life on the bank of a body of water (Wagner & Hagan, 2000).

The National Water Act, 1998 (Act No. 36 of 1998) also defines riparian areas as: "Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas"

The delineation of the riparian edge does not follow the same methodology, as is the case with wetlands. The riparian edge is demarcated using the physical structure of the vegetation found in the riparian area, as well as the micro topographical location of the riparian characteristics. In riparian areas, the increased water available to the plants (living in this area) has created a habitat with greater vegetation growth potential. This boundary of greater growth is used to delineate the riparian edge (Figure 2).

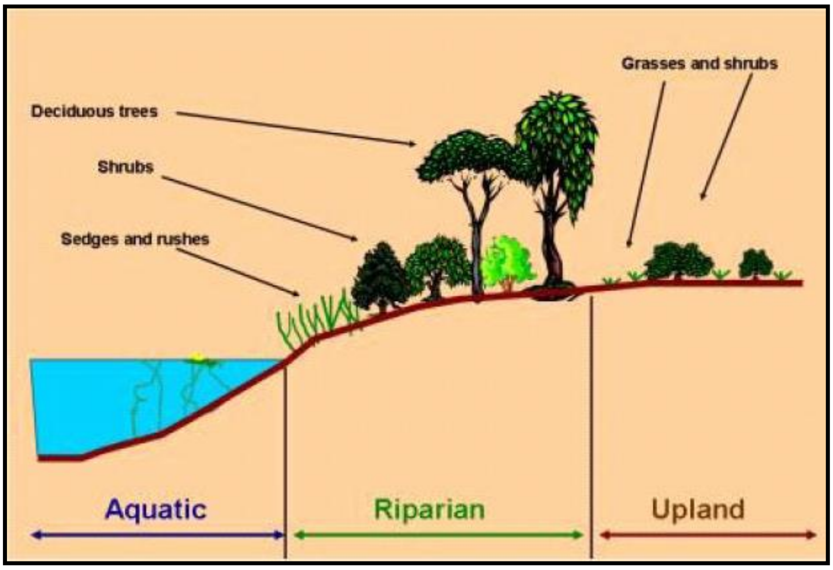

FIGURE 2: SKETCH INDICATING A CROSS SECTION OF RIPARIAN ZONATION COMMONLY FOUND IN SOUTH AFRICA – WWW.EPA.GOV/

The delineation guideline, Department of Water Affair's: Practical field procedure for identification and delineation of wetlands and riparian areas, Edition 1 September 2005, and revision 2 of 1998 was used. **The site visit was conducted on various dates in 2019, 2020, 2021 and 2022. All field work was completed by the author and the data is assimilated into this report.** This identification and delineation of possible wetlands and riparian habitat is also done to mitigate any possible future contraventions of the National Water Act, Act no 36 of 1998.

Although the term wetland describes the main *functions* provided by the wetland, there are many different hydrogeomorphic *types* of wetlands in South Africa. The following table (Table 1) from Kotze, et al. 2007 illustrates the type of wetland as well as the hydrological source of the wetland. Important is Table 2 concerning the regulatory benefits provided by the wetland types.

Table 1: The Wetland hydrogeomorphic (HGM) types typically supporting inland wetlands in South Africa (from Kotze, *et al.* 2007)

Hydrogeomorphic (HGM) types		Description	Source of water maintaining wetland	
			Surface	Subsurface
Floodplain		Valley bottom areas with a well-defined stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/***
Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and from adjacent slopes	***	*/***
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defines stream channel connecting the area directly to a stream channel.	*	***
Isolated hillslope seepage		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel	*	***

Hydrogeomorphic (HGM) types		Description	Source of water maintaining wetland	
			Surface	Subsurface
Depression (including Pans)		A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e., it is inward draining). It may also receive sub-surface water. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.	*/***	*/***

Precipitation is an important water source and evapotranspiration an important output in all the above settings.

indicates wetland

Water source:

* Contribution usually small

*** Contribution usually large

*/ *** Contribution may be small or important depending on the local circumstances

*/ *** Contribution may be small or important depending on the local circumstances.

TABLE 2: THE REGULATORY BENEFITS POTENTIALLY PROVIDED BY WETLANDS (FROM KOTZE ET AL. 2007)

Wetland Hydrogeomorphic types (HGM)	Regulatory benefits potentially provided by wetland							
	Flood Attenuation		Stream-flow regulation	Enhancement of Water Quality				
	Early Wet Season	Late wet season		Erosion control	Sediment Trapping	Phosphates	Nitrates	Toxicants
Floodplain	**	*	0	**	**	**	*	*
Valley bottom-channelled	*	0	0	**	*	*	*	*
Valley bottom unchannelled	*	*	*?	**	**	*	*	**
Hillslope seepage connected to a stream	*	0	*	**	0	0	**	**
Isolated hillslope seepage	*	0	0	**	0	0	**	*
Pan/ Depression	*	*	0	0	0	0	*	*

Rating: 0 Benefit unlikely to be provided to any significant level

* Benefit likely to be present as least to some degree

** Benefit very likely to be present (and often supplied to a high level)

1.1. Buffers or setbacks

Buffer areas are part of the aquatic ecosystem and may not be developed or affected in any way by the construction activities and is rated the same sensitivity as the system. Buffers are a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, to reduce the impact of adjacent land uses on the wetland or riparian area (Figure 3.

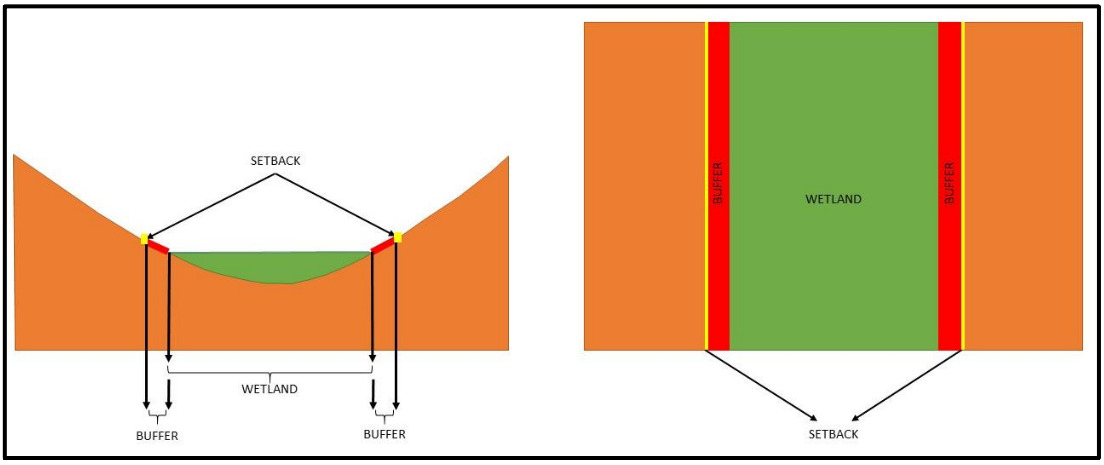

FIGURE 3: LAYOUT OF A TYPICAL BUFFER AROUND A WETLAND WITH THE SETBACK LINE CLEARLY DEFINED

Buffers are a fabricated ecotone. This ensures the wetland functioning is kept at an optimum and the services provided by wetlands are maintained. To ensure the buffer is maintained it must be fenced off prior to the physical construction of the site and the building contractors of the site contractually bound to the conservation of the area.

1.2. Scope of work

The scope of this project is:

- Delineation aquatic ecosystems,
- Assessment of the wetland and riparian conditions on site and within 500 m of the extended study area (ESA),
- Conduct a wetland functional assessment which includes the Present Ecological State (PES) of the wetland feature and riparian features, Ecological Importance and Sensitivity (EIS) and Ecoservices of the systems,
- Determine the environmental impacts of the diversion
- Complete the DWS Risk Assessment for the diversion, process plant and new offices,
- Suggested buffer zones and mitigation measures to limit the impacts to the aquatic ecosystem,
- Compile all Maps & Shapefiles accompanying the reports. These can be obtained from Limnology Pty. Ltd.[2]

[2] Limnology. 082 921 5445 bertusfourie@gmail.com

2. Assumptions and limitations

To determine the riparian or wetland boundary, indicators (as discussed above) are used. If these are not present during the site visit, it can be assumed that they were dormant or absent and thus if any further indicators are found during any future phases of the project, the author cannot be held responsible due to the indicator's variability. Even though every care was taken to ensure the accuracy of this report, environmental assessment studies are limited in scope, time, and budget. Discussions and proposed mitigations are to some extent made on reasonable and informed assumptions built on *bona fide* information sources, as well as deductive reasoning. The safety of the delineator is of priority and thus in areas deemed, as unsafe limited time was spent. If the location of the study site is on and near underlying granitic geology the possible presence of cryptic wetlands must be investigated by a suitably qualified soil scientist with field experience.

Deriving a 100% factual report based on field collecting and observations can only be done over several years and seasons to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage.

As aquatic systems are directly linked to the frequency and quantity of rain it will influence the systems drastically. If during dry months or dry seasons studies are done, the accuracy of the report's findings could be affected.

Limnology can thus not accept responsibility for conclusions and mitigation measures made in good faith based on own databases or on the information provided at the time of the directive. This report should therefore be viewed and acted upon with these limitations in mind.

3. Site location and description

The study site is located around 26° 9'28.88"S 29°20'39.50"E (Figure 4).

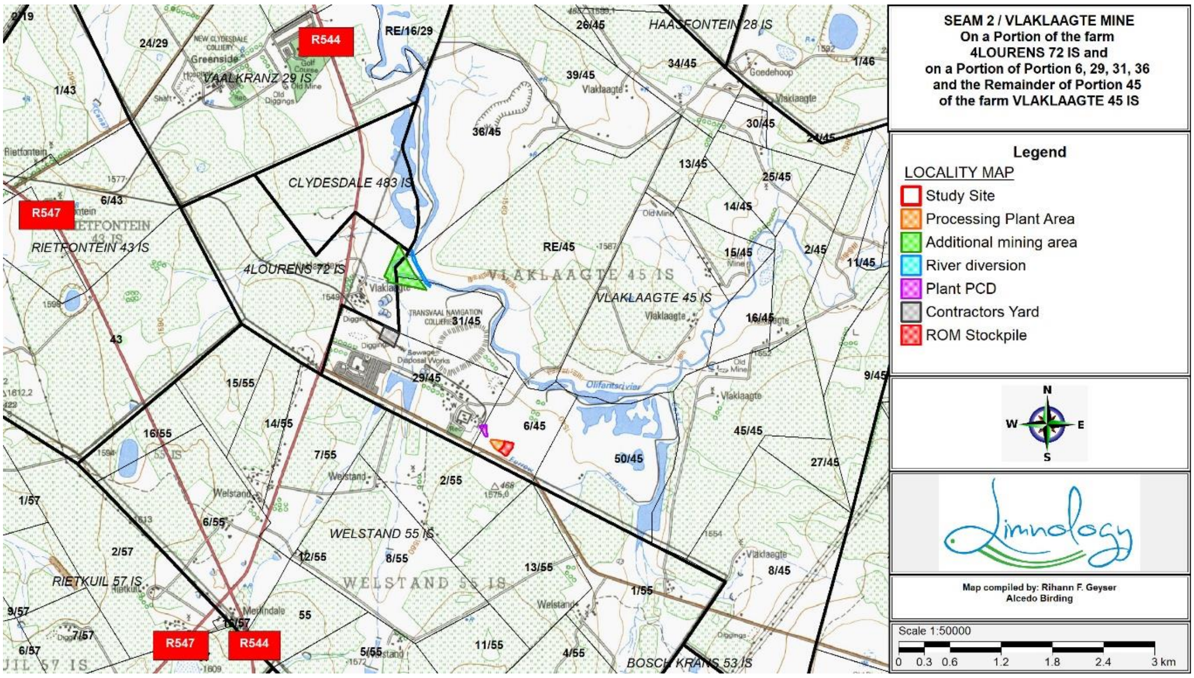

FIGURE 4: STUDY SITE LOCATION

3.1. Proposed Activities

Diversion of the Olifants River for coal mining operations with additionally new processing plant and run of mine stockpile, tailings facility, contractor yard and two pollution control dams.

3.2. Regional description and vegetation

Mucina & Rutherford (2006) classified the area as Gm 12 Eastern Highveld Grassland. It is found on slight to moderately undulating plains, as well as low hills and pan depressions. The vegetation is short dense grassland, and it is dominated by Highveld grass composition (*Aristida, Digitaria, Eragrostis, Themeda, Tristachya*, etc.) with small, scattered rocky outcrops with wiry, sour grasses and some woody species for instance the *Senegalia caffra, Celtis africana, Diospyros lycioides* subsp. *lycioides, Parinari capensis, Protea caffra, P. welwitschii* and *Searsia magalismontanum*.

Very dry winters with strongly seasonal summer rainfall. MAP 650-900mm (overall average: 726mm), MAP relative uniform across most of this unit, but increases significantly in the extreme southeast. The coefficient of variation in MAP is 25% across most of the unit. It drops to 21% in the east and southeast. Incidents of frost occur from 13-42 days, but even higher at higher elevations.

It is considered endangered – target 24%. Only a very small fraction is conserved in statutory reserves (Nooitgedacht Dam and Jericho Dam Nature Reserves) and in the private reserves Holkranse, Kransbank, Morgenstond. Some 44% is primarily transformed by cultivation, plantations, mines, urbanisation and by building of dams. Land-cover data indicates that cultivation may have had a more extensive impact. Although no serious alien invasions are reported, *Acacia mearnsii* can become dominant in disturbed sites.

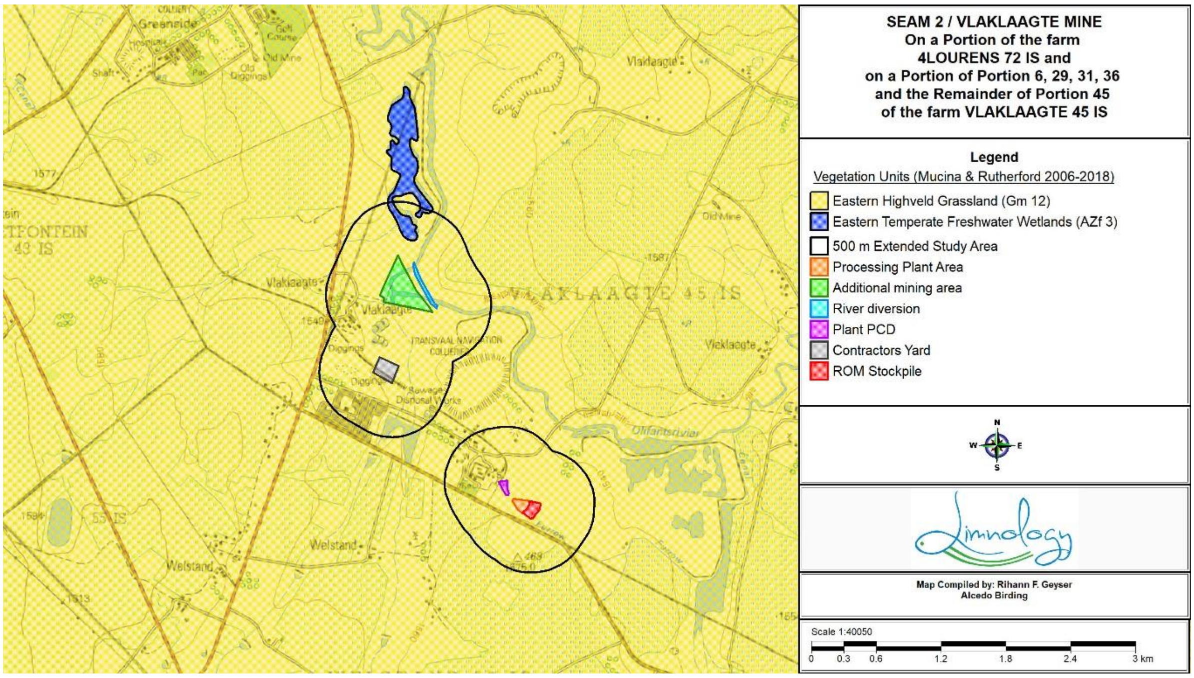

FIGURE 5: THE VEGETATION TYPES OF THE STUDY AREA

3.3. Catchment and ecoregion description

The study area falls in the Olifants (WMA no 3) and is in quaternary catchments B11B. The quaternary catchment B11B has a mean annual precipitation of 687.26mm and mean annual runoff of 36.2%. The study site drains directly to the Olifants River. See Figure 6 below for the Google Earth description of the site, as provided by the Department of Water Affair's Resource Quality Services (RQS) department.

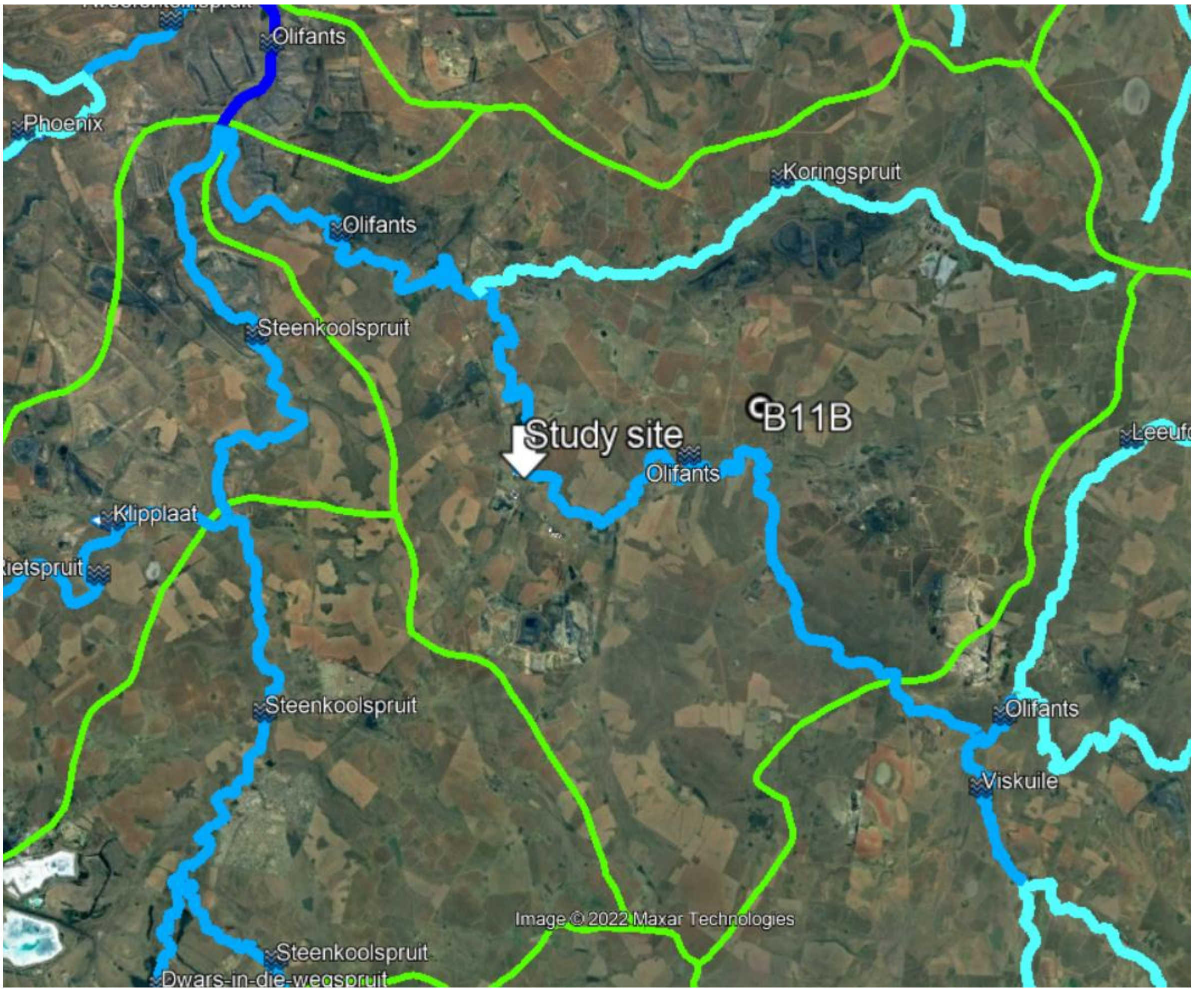

FIGURE 6: THE CATCHMENT AND HYDROLOGICAL DATA FOR THE STUDY SITE, AS AVAILABLE FROM DWA RQS SERVICES

3.4. Ecoregion

The site falls within the **Highveld Ecoregion** (Figure 7) as described in the Level 1 Ecoregions by the Department of Water Affairs and Forestry (DWAF, 2005):

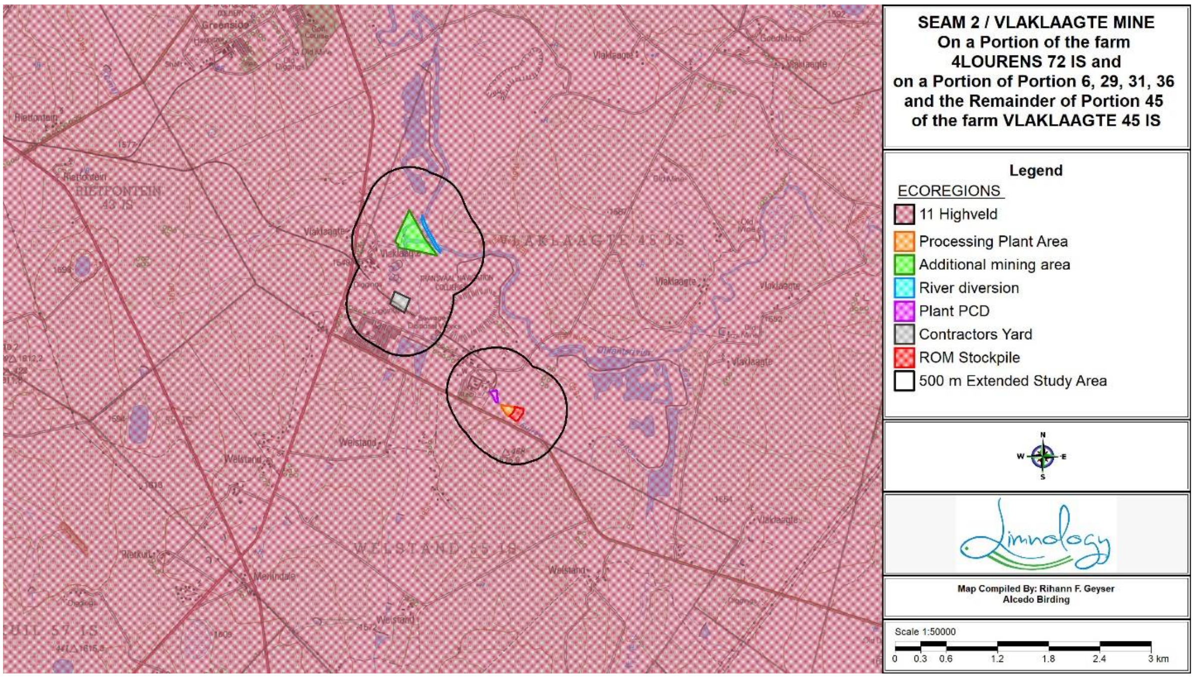

FIGURE 7: ECOREGIONS OF THE STUDY SITE

3.4.1. Ecoregion Primary boundary determinants:

Plains with a moderate to low relief, as well as various grassland vegetation types (with moist types present towards the east and drier types towards the west and south), define this high lying region.

3.4.2. Ecoregion general:

Several large rivers have their sources in the region, e.g., Vet, Modder, Riet, Vaal, Olifants, Steelpoort, Marico, Crocodile (west), Crocodile (east) and the Great Usutu. The level 1[3] description of the Water Management Area, as from DWAF, 2007 lists the system as part of the Crocodile (West) River and is characterised by the following:

This is generally a low laying, dry to arid, hot region with virtually no perennial streams originating in the area itself. Perennial rivers that traverse this region include the Crocodile (west), Marico, Mokolo, Lephalala, and Mogalakwena.

- Mean annual precipitation: Low to arid.

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[3]**Level I:** This level of typing is based on the premise that ecosystems and their components display regional patterns that are reflected in spatially variable combinations of causal factors such as climate, mineral availability (soils and geology), vegetation and physiography. In South Africa physiography, climate, geology, soils, and potential natural vegetation have been used as the delineators of Level I (DWAF, 2007).

- Coefficient of variation of annual precipitation: Moderately high to high
- Drainage density: Mostly low but with some areas in the north having a high drainage density.
- Stream frequency: Mostly low to medium, but high in north-eastern areas.
- Slopes <5%: Generally, >80% of the area.
- Median annual simulated runoff: Very low to low.
- Mean annual temperature: High to very high

3.1. DWS RQS PES EI and ES inventory

The DWS reserve quality services (RQS) data is given in Figure 8. This sets the PES of reach 1327 to “C”. The Ecological Integrity and Ecological Services is both “High” for the reach.

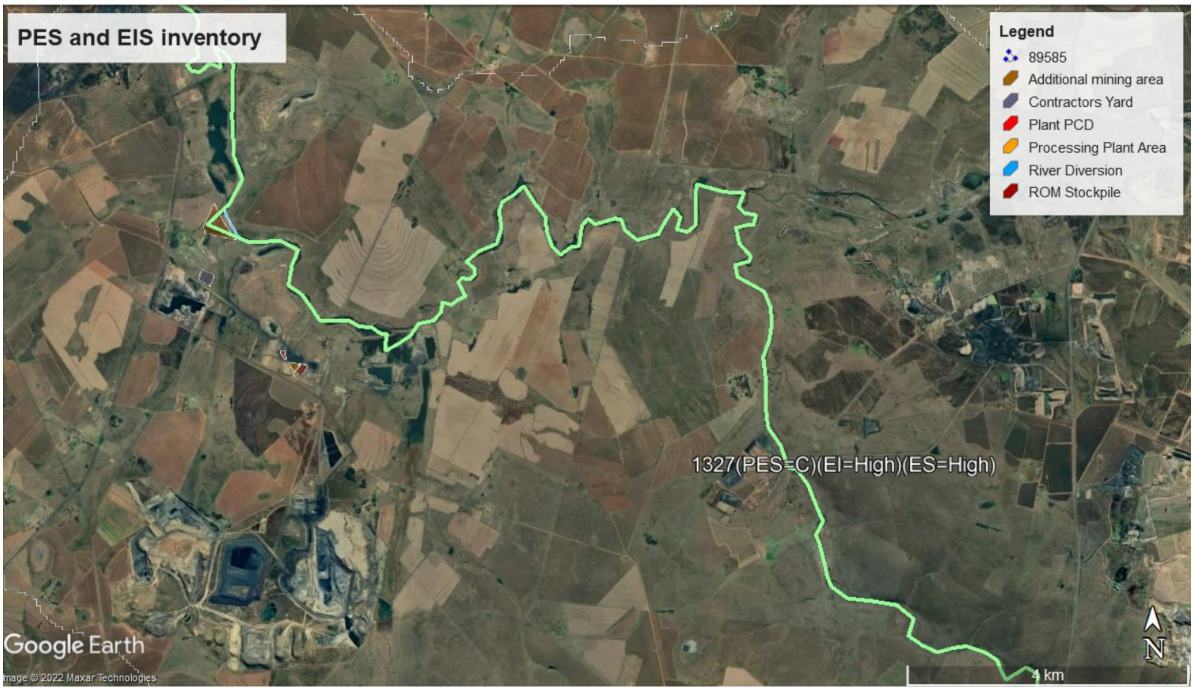

FIGURE 8: DWS RQS DATA FOR THE REACH 1327.

4. Methodology

4.1. River diversion assessment methodology

To determine the impact of a river diversion is difficult, as other similar studies with the same scope of work is limited. Many European and American examples was found (Gilvear D.J., 1999), but these must be applied with care as they are based on systems completely outside South African ecosystem drivers.

To assess the *in-situ* conditions, before the diversion, firstly the drivers of the aquatic ecosystem were measured. This includes basic aspects, such as stream morphology, water quality assessment and physical structures. This information is then used to describe the habitat created by the system, where the diversion is planned. See Table 3 for a description of the drivers.

TABLE 3: METHODS TO MEASURE DRIVERS/ ABIOTIC FACTORS

Drivers/ Abiotic	
Aspect	**How**
Chemical	Water quality assessment using handheld probe and laboratory assessments
Physical	Water column, bank height and shape and morphology were simply measured and calculated using common knowledge methods. This includes fauna and flora identification.

The reagent to the drivers is basically the fauna and flora occurring in the specific area where the diversion is planned. To assess the reagents, basic EcoStatus models were applied (Louw and Kleynhans, 2007). This includes SASS 5 and fish population assessments. See Table 4 for the methods employed to determine the reagents to the drivers.

TABLE 4: METHODS TO MEASURE REAGENTS TO DRIVERS

Reagents to drivers	
Aspect	**How**
Fauna	Benthic fauna in line with SASS 5 methods (Dickens and Graham, 2002)
Flora	Species identification per sample site in line with VEGRAI methods (Louw and Kleynhans, 2007). Population densities estimated visually
Habitat	Description of habitats in line with (Dickens and Graham, 2002) and (Kleynhans and Louw, 2008)

This information is then used to interpret results and provide management information. This includes ecological goods and services as well as the methods employed to determine the reagents to the drivers. See Table 5 for methods

TABLE 5: METHODS TO INTERPRET INFORMATION

Reagents to drivers	
Aspect	**How**
Goods and services	Using method and program as described by (Breen, Uys and Batchelor, 2008)

See sections below for detailed description of methods employed for the assessments.

4.1.1.Abiotic drivers

4.1.1.1. Chemical drivers: Laboratory assessment

All sampling of water quality is done in accordance with the Department of Water and Sanitation's guide: Quality of domestic water supplies Volume 2: Sampling Guide I (DWAF, 1996). See Figure 9 for an image of the sampling procedure as taken from the guide.

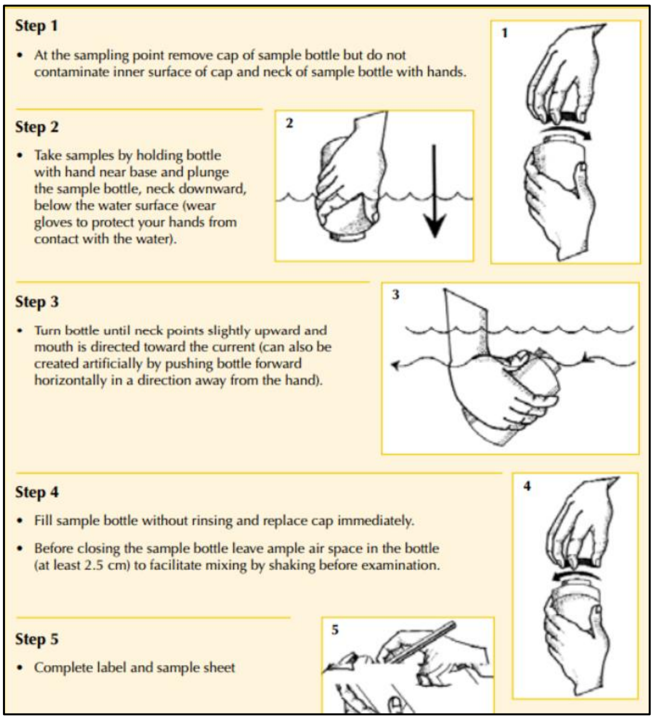

FIGURE 9: WATER SAMPLING PROCEDURE

4.1.1.2. Chemical drivers: Handheld probe

In addition to laboratory assessment of water quality, sampling was also completed using a Hanna handheld probe- HI 9813-5 Portable pH, EC, TDS, Temperature (°C) meter. The probe is placed in water and a minimum of one minute is timed. Results are reviewed until readings on the LCD screen is stable.

4.1.1.3. Interpretation of physical properties of water

The physical properties of water are based on the temperature, Electrical conductivity (EC)/ Total dissolved solids (TDS) and pH. The physical properties of water influence the aesthetical – as well as the chemical qualities of water. Relevance of the indicators of the physical properties of water include pH- affects the corrosiveness of water and EC- an indication of the "freshness" of water (indicates the presence of dissolved salts and other dissolved particles). Included in the physical properties of water is the suspendoid's effects on water quality. This includes turbidity, and total suspended solids. See Table 6 for a list of physical properties of water and comparative results.

TABLE 6: TABLE FOR COMPARATIVE RESULTS OF PHYSICAL PROPERTIES OF WATER

pH Values	
pH > 8.5	Alkaline
pH 6.0-8.5	Circumneutral
pH < 6.0	Acidic
Total Dissolved Solids as indicator of salinity of water	
TDS <450 mg/l	Non saline
TDS 450-1000 mg/l	Saline
TDS 1000-2400 mg/l	Very saline
TDS 2400-3400 mg/l	Extremely saline
Total suspended solids (TSS)	
Background TSS concentrations are < 100 mg/l	Any increase in TSS concentrations must be limited to < 10 % of the background TSS concentrations at a specific site and time.

4.1.1.4. Physical

To determine the physical aspect of the diversion, two aspects was measured- firstly, the bank morphology of the system above water and secondly, the bathometric topography. To assess the above water bank morphology, a dumpy level was used to determine the height of the bank to the water level. Secondly, the distance from the edge of the bank's vertical point to the edge of the banks horizontal point was measured. This was then used to graphically show the slope of the bank.

For the bathometric assessment a Deeper Pro[4] Sonar, set to boat mode was used. This information is then automatically sent to the Deeper Lakebook[5] website, for analysis. Other aspects such as fish presence and size could also be extrapolated from this information.

4.1.1.5. Bank morphology

The methods for bank morphology classification was adapted from (Rowntree and Wadeson, 2000; Dallas, 2005). Using the cross-sectional diagram (Figure 10) from (Dallas, 2005) the following features are described:

- *High terrace (rarely inundated):* relict floodplains which have been raised above the level regularly inundated by flooding, due to lowering of the river channel.
- *Terrace (infrequently inundated):* area raised above the level regularly inundated by flooding.
- *Flood bench (inundated by annual flood):* area between active and macro-channel, usually vegetated.
- *Side bar:* accumulations of sediment associated with the channel margins or bars forming in meandering rivers where erosion is occurring on the opposite bank to the bar.
- *Mid-channel bar:* single bar(s) formed within the middle of the channel; flow on both sides.
- *Island (vegetated)*: island formed within the middle of the channel that is vegetated; flow on both sides.
- *Secondary or lateral channel:* a second channel that flows adjacent to the primary channel.
- *Flood plain (inundated by annual flood):* a relatively level alluvial (sand or gravel) area lying adjacent to the river channel which has been constructed by the present river in its existing regime.
- *Hillslope abutting on to the active channel*

[4] https://deepersonar.com/us/

[5] https://maps.deepersonar.com/us/

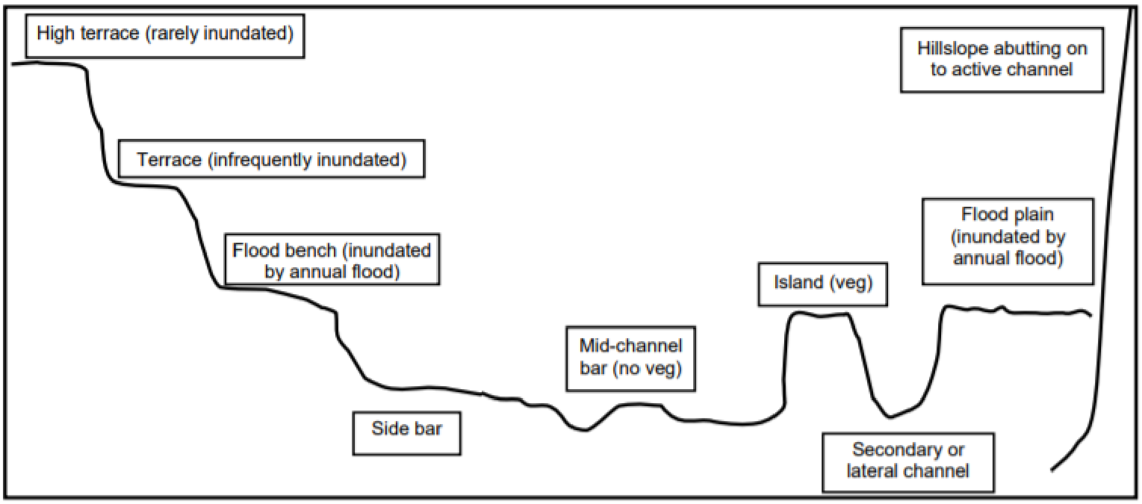

FIGURE 10: CROSS SECTIONAL DIAGRAM SHOWING RELEVANT CHANNEL FEATURES

4.1.2. Biotic reagents

4.1.2.1. Fish population response assessment

The fish population response assessment is done using the Fish Response Assessment Index (FRAI), which consists of 8 steps as described by (Kleynhans, 2007c) (Table 7).

TABLE 7: THE EIGHT STEPS OF FRAI AS DESCRIBED BY KLEYNHANS, 2007

Steps 1-8	Procedure
Step 1: Selection of river for assessment	As for study requirements and design
Step 2: Determination of the reference fish assemblage	Use historical data & expert knowledge Model: use ecoregions and other environmental information Use expert fish reference frequency if occurrence database if available
Step 3: Determination of the present state of drivers	Hydrology Physico-chemical Geomorphology *Or* Index of habitat integrity
Step 4: Selection of representative sampling sites	Field survey in combination with other survey activities
Step 5: Determination of fish habitat condition	Assess fish habitat potential Assess fish habitat condition
Step 6: Fish sampling	Sample all velocity depth classes per site if feasible

Steps 1-8	Procedure
	Sample at least three stream sections per site.

4.1.2.2. Ichnofauna habitat assessment

The velocity depth classification of the site in terms of fish habitat as described by (Kleynhans, 1991; Barbour *et al.*, 1998; Dallas, 2005) will be completed. This is based on the descriptor abundance of velocity-depth class and cover types.

TABLE 8: FISH HABITAT ASSESSMENT FORM

Estimate abundance of each velocity-depth class and cover type using the scale: 0 – absent; 1 – rare; 2 – sparse; 3 – common; 4 - abundant; 5 – very abundant

SLOW DEEP:	Slow shallow:	Fast deep:	**FAST SHALLOW:**
Overhanging vegetation:	Overhanging vegetation:	Overhanging vegetation:	Overhanging vegetation:
Undercut banks & root wads:	Undercut banks & root wads:	Undercut banks & root wads:	Undercut banks & root wads:
Substrate:	Substrate:	Substrate:	Substrate:
Aquatic macrophytes:	Aquatic macrophytes:	Aquatic macrophytes:	Aquatic macrophytes:
Water Column:	Water Column:	Water Column:	Water Column:
Remarks:	Remarks:	Remarks:	Remarks:

4.1.2.3. SASS 5 method

In South Africa, the River Health Programme (under the Department of Water Affairs) has developed a suite of different programs to rapidly assess the quality of aquatic systems. One of the most popular and robust indicators of aquatic ecology health is the South African Scoring System or SASS currently in version 5 (SASS5).

The South African Scoring System is a biotic index initially developed by Chutter (1998). It has been tested and refined over several years and the current version is SASS 5 (Dickens and Graham, 2002). This technique is based on a British biotic index called the Biological Monitoring Working Party (BMWP) scoring system and has been modified to suit South African aquatic micro-invertebrate fauna and conditions. SASS 5 is a rapid biological assessment method developed to evaluate the impact of changes in water quality using aquatic macro-invertebrates as indicator organisms. SASS is widely used as a bio-assessment tool in South Africa because of the following reasons:

- It does not require sophisticated equipment
- Method is rapid and relatively easy to apply.
- This method is very cheap in comparison to chemical analysis of water samples and analysis and interpretation of output data is simple.
- Sampling is generally non-destructive, except where representative collections are required, (the biodiversity index of SASS5 is described in Dickens and Graham (2002).
- It provides some measure of the biological status of rivers in terms of water quality.

SASS is therefore a method for detection of current water quality impairment and for monitoring long-term trends in water from an aquatic invertebrate's perspective. Although SASS 5 is user-friendly and cheap, it has some limitations. The method is dependent on the sampling effort of the operator and the total SASS score is greatly affected by the number of biotopes sampled.

SASS 5 is not accurate for lentic conditions (standing water) and should be used with caution in ephemeral rivers (systems that do not always flow) (Dickens and Graham, 2002) The resolution of SASS 5 is at family level; therefore, changes in species composition within the same family due to environmental changes cannot be detected.

Although the SASS 5 score acts as a warning 'red flag' for water quality deterioration, it cannot pinpoint the exact cause and quantity of a change. SASS5 does not cover all invertebrate taxa. SASS also cannot provide information about the degradation of habitat, so habitat assessment also indices, to show the state of the habitat. The initial SASS protocol was described by Chutter (1998) and refined by Dickens and Graham (2002) require collections of macro-invertebrates from a full range of biotopes available at each site.

The biotopes sampled include vegetation both in and out of current (VG- aquatic and marginal), stones (S- both stones in current and out of current) and gravel, sand, and mud (GSM) (Dickens & Graham, 2002). The standardised sampling methods allow comparisons between studies and sites. Macro-invertebrate sampling is done using a standard SASS net (mesh size 1000 mm, and a frame of 30 cm x 30 cm). There are nineteen (19) possible macro-invertebrates from each biotope that are tipped into a SASS tray half filled with water and families are identified for not more than 15 minutes/biotype at the streamside.

4.1.2.4. Flora

Basic flora identification was completed by this specialist on site using a strip transect method as per the sample transects. It must be noted that species identification could possibly be erroneous, but a high degree of confidence is attached to the identification.

4.2. Impact assessment

The methodology used to assess the significance of an impact is based on the requirements as set out in EIA Regulations, (GN 982) of 2014 in terms of the NEMA as well as the Proposed National Guideline on Minimum Information Requirements for Preparing EIA for Mining Activities that Require EA, of 2018, GN 86 in terms of NEMA. The impact significance methodology described below also complies to Appendix B of the Operational Guideline to Integrated Water and Waste Management of 2010 in terms of the NWA. In the event of any Section 21c&i water uses in terms of the NWA being assessed, Appendix A of the General Authorisations of 2016, GN 509 in terms of the NWA will be used to construct a risk matrix. Regulation 3(b) of the General Authorisations of 2016, GN 509 in terms of the NWA states that a suitably qualified SACNASP professional member must determine risks associated with this risk matrix.

4.2.1. Method of impact assessment

Impact identification and prediction is a stepwise procedure to identify the direct, indirect, and cumulative impacts (relating to both positive and negative impacts) for which a proposed activity and its alternatives will have on the environment as well as the community. This should be undertaken by determining the geographical, physical, biological, social, economic, heritage and cultural sensitivity aspects of sites and locations as well as the risk of impact of the proposed activity. Refer to part A(h)(iv) for a complete description of these environmental attributes. Sources of data to be used for gathering data on the environmental attributes as well as the impacts include monitoring / sampling data collected and stored, assumptions and actual measurements, published data available from the departments or other stakeholders in the area as well as specialist studies. Likely impacts should be described qualitatively and then studied separately in detail. This provides consistent and systematic basis for the comparison and application of judgements.

4.2.2. Significance ratings

Ratings should then be assigned to each criterion. Significance of impacts should be determined for each phase of the mining lifecycle this includes preconstruction, construction, operational, closure (including decommissioning) and post closure phases. The significance of impacts should further be assessed both with and without mitigation action. The description of significance is largely judgemental, subjective, and variable. However, generic criteria can be used systematically to identify, predict, evaluate, and determine the significance of impacts resulting from project construction, operation, and decommissioning. The process of determining impact magnitude and significance should never become mechanistic. Impact magnitude is determined by empirical prediction, while impact significance should ideally involve a process of determining the acceptability of a predicted impact to society. Making the process of determining the significance of impacts more explicit, open to comment and public input would be an improvement of environmental assessment practice. Impact magnitude and significance should as far as possible be determined by reference to either legal requirements (accepted scientific standards) or social acceptability. If no legislation or scientific standards are available, the EAP can evaluate impact magnitude based on clearly described criteria. A matrix selection process is the most common methodology used in determining and ranking the site sensitivities:

4.2.2.1. The consequence

Includes the nature / intensity / severity of the impact, spatial extent of the impact, and duration of the impact.

- The nature / intensity / severity of the impact: An evaluation of the effect of the impact related to the proposed development on the receiving environment. The impact can be either positive or negative. A description should be provided as to whether the intensity of the impact is high, medium, or low or has no impact in terms of its potential for causing negative or positive effects. Cognizance should be given to climate change which may intensify impacts.
- The spatial extent of the impact: Indication of the zone of influence of the impact: A description should be provided as to whether impacts are either limited in extent or affect a wide area or group of people. Cumulative impacts must also be considered as the extent of the impact as may increase over time.
- The duration of the impact: It should be determined whether the duration of an impact will be short-term, medium term, long term or permanent. Cumulative impacts must also be considered as the duration of the impact as it may increase over time.

4.2.2.2. The likelihood

Includes the probability of the potential occurrence of the impact, and frequency of the potential occurrence of the impact

- The probability of the impact: The probability is the quality or condition of being probable or likely. The probability must include the degree to which these impacts can be reversed; may cause irreplaceable loss of resources; and can be avoided, managed, or mitigated
- The frequency of the potential occurrence of the impact.

4.2.2.3. The significance:

This is worst case scenario without any management measures. See below how significance is determined: Impact that may have a notable effect on one or more aspects of the environment or may result in noncompliance with accepted environmental quality standards, thresholds or targets and is determined through rating the positive and negative effects of an impact on the environment based on criteria such as duration, magnitude, intensity, and probability of occurrence. Mitigation measures should be provided with evidence or motivation of its effectiveness. Example of significance ratings are given in Table 9 and TABLE 10.

TABLE 9: PRIOR TO MITIGATION IMPACT ASSESSMENT

Intensity and magnitude	1 Natural processes or functions are not affected and will adequately return to its natural state. The impact will be completely reversed with correct management, and can be completely avoided, managed, or mitigated.	2 Natural processes or functions are affected, and natural processes or functions will continue in a modified manner. The impact will be reversed to some degree with correct management, and can be somewhat avoided, managed, or mitigated	3 Natural processes or functions are to the extent where it temporarily or permanently ceases. The impact cannot be reversed even with correct management, and cannot be avoided, managed, or mitigated
Resource replaceability	1 Loss of resource can be completely replaced.	2 Loss of resource can somewhat be replaced.	3 Resources will be completely lost.
Duration	1 The impact will be short-lived.	2 The impact will last for the entire operational life of the activity but will be mitigated thereafter.	3 The impact will not cease after the operational life of the activity ceases but will be permanent.
Extent or spatial scale	1 The impact will be site specific.	2 The impact will affect the local area.	3 The impact will affect an area larger than just the local area.
Probability	1 It is unlikely that the impact will occur.	2 There is a probability for the impact to occur.	3 The impact will occur.

Significance	None or low If the sum of the above ranking is equal or more than 5 and 7, and no ranking equals 3.	Medium If the sum of the above ranking is equal or more than 8 to 11.	High If the sum of the above ranking is 12 or more.

TABLE 10: POST MITIGATION IMPACT ASSESSMENT

Intensity and magnitude	1 Natural processes or functions are not affected and will adequately return to its natural state. The impact will be completely reversed with correct management, and can be completely avoided, managed, or mitigated.	2 Natural processes or functions are affected, and natural processes or functions will continue in a modified manner. The impact will be reversed to some degree with correct management, and can be somewhat avoided, managed, or mitigated	3 Natural processes or functions are to the extent where it temporarily or permanently ceases. The impact cannot be reversed even with correct management, and cannot be avoided, managed, or mitigated
Resource replaceability	1 Loss of resource can be completely replaced.	2 Loss of resource can somewhat be replaced.	3 Resources will be completely lost.
Duration	1 The impact will be short-lived.	2 The impact will last for the entire operational life of the activity but will be mitigated thereafter.	3 The impact will not cease after the operational life of the activity ceases but will be permanent.
Extent or spatial scale	1 The impact will be site specific.	2 The impact will affect the local area.	3 The impact will affect an area larger than just the local area.
Probability	1 It is unlikely that the impact will occur.	2 It is likely for the impact to occur.	3 The impact will occur.
Significance	None or low If the sum of the above ranking is equal or more than 5 and 7, and no ranking equals 3.	Medium If the sum of the above ranking is equal or more than 8 to 11.	High If the sum of the above ranking is 12 or more.

4.3. GN 509 (Department Of Water Affairs And Sanitation, 2016)

GN 509 (Department of Water Affairs and Sanitation, 2016) is an excel based program using various risk assessments keys to calculate the overall risk assessment of any proposed activities. It must be noted that the excel spreadsheet provided by DWS is not used as the auto-calculation functions, highlighter and other esthetical aspects cannot be edited. This makes for the operational use of the document very difficult. Instead, the author has devised his own excel spreadsheet allowing for more accurate assessment of the risk assessment.

To assess the risk assessment of the project, the first basic aspects assessed is the Phases, Activity, and Impact. These are alphabetical impact descriptions of the impact ratings rosters. They describe the calculations of the impact ratings. Various ratings keys are used to determine the risk assessment. This includes Severity, Consequence and Likelihood to calculate the significance.

4.3.1.Severity

Calculations of the severity of the impact using ratings from 1-5 for Flow Regime, Physico & Chemical (Water Quality), Habitat (Geomorphic and Vegetation) and Biota. The ratings scale is given in TABLE 11

TABLE 11: SEVERITY

Insignificant/ non- harmful	1
Small/ potentially harmful	2
Significant/ slightly harmful	3
Great/ Harmful	4
Disastrous/ Extremely harmful	5

4.3.2.Consequence

Calculation of consequence is done by assessing Spatial scale and duration, using the following tables (TABLE 12 and TABLE 13):

TABLE 12: SPATIAL SCALE

Area specific (at impact site)	1
Whole site (entire surface right)	2
Regional. Neighbouring areas (Downstream within quaternary catchment)	3
National (impact beyond secondary catchment or province)	4
Global (beyond SA boundary)	5

TABLE 13: DURATION

One day to one month (PES, EIS not impacted)	1
One month to one year (PES, EIS impacted but no change in status)	2

One year to 10 years (PES, EIS impacted to lower status, but can improve over this time with mitigation)	3
Life of the activity (PES, EIS permanently lowered)	4
More than life of the organisation/ facility (PES, EIS a E or F)	5

4.3.3. Likelihood

To calculate likelihood, the Frequency of activity (TABLE 14) is added to the Frequency of impact (TABLE 15), Legal Issues (TABLE 16) and Detection (TABLE 17).

TABLE 14: FREQUENCY OF THE ACTIVITY

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

TABLE 15: FREQUENCY OF THE INCIDENT/ IMPACT

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

TABLE 16: LEGAL ISSUES

No legislation	1
Fully covered by legislation (wetland are legally governed)	5

TABLE 17: DETECTION

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

4.3.4.Calculations of the risk assessment

See TABLE 18 for the calculation of the significance or risk assessment calculations. Using the ratings class in TABLE 19 the risk profiling can be compiled.

TABLE 18: CALCULATIONS

Consequence= Severity + spatial scale + duration
Likelihood= Frequency of activity + Frequency of incident + legal issues + Detection
Significance/ risk= Consequence x Likelihood

TABLE 19: RATINGS CLASS

1-55	Low risk	Acceptable as is or requirement of mitigation. Impact on watercourse and resource quality small and easily mitigated
56-169	Moderate risk	Risk and impact on watercourse are notably and require mitigation measures on a higher level, which cost more and require specialist input. License required.
170-300	High risk	Watercourse impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the reserve. License required.

4.3.5.Confidence

Indicate confidence level of scores provided in the last column as a percentage from 0-100%.

5. Results

Historically the site was undermined for the old Transvaal-Natal Coal Mine. Various other incarnations of mining have through the years taken place on the site. The current owner of the property is mining via open cast mining the board and pillars of the old underground mining operations. This report is written to assess the impact of diverting the Olifants River to allow for the opencast mining of remaining sections under the river (Figure 11) as well as other proposed activities including new processing plant, tailings facility, contractor yard and the two pollution control dams (Figure 12).

FIGURE 11: PROPOSED MINING AREA AND RIVER DIVERSION

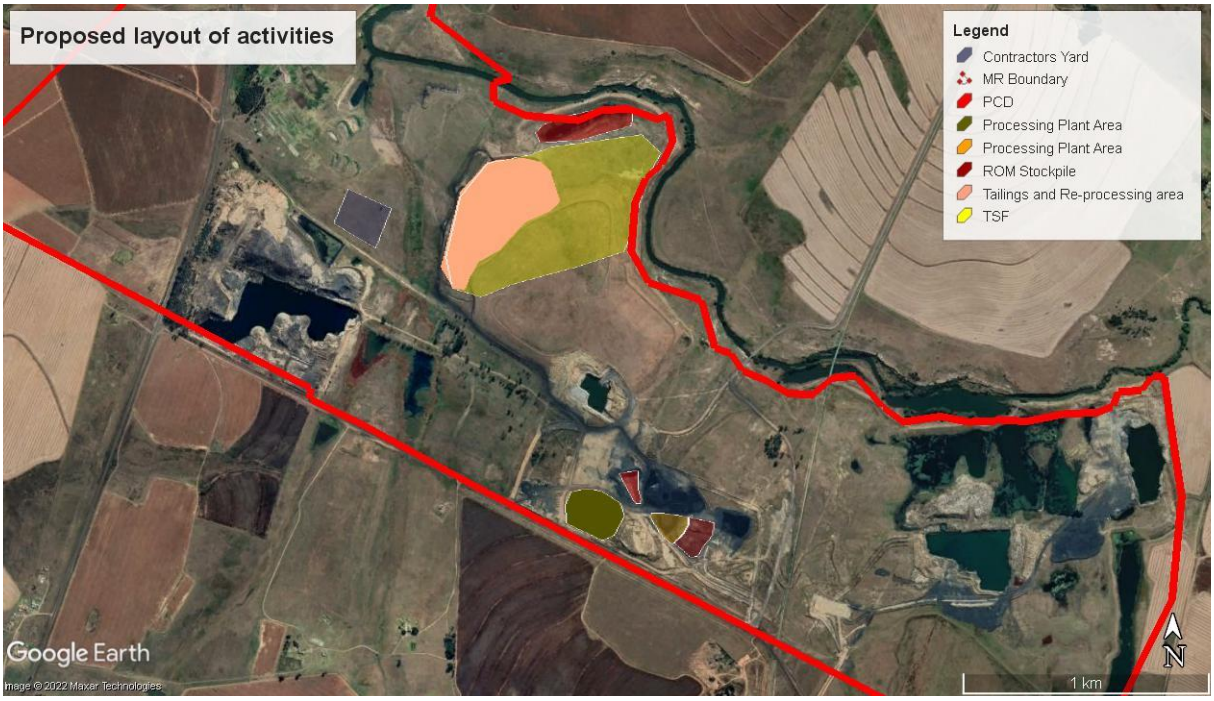

FIGURE 12: PROPOSED LAYOUT OF ADDITIONAL ACTIVITIES

Various aquatic ecosystems have been identified within the study site (Figure 13).

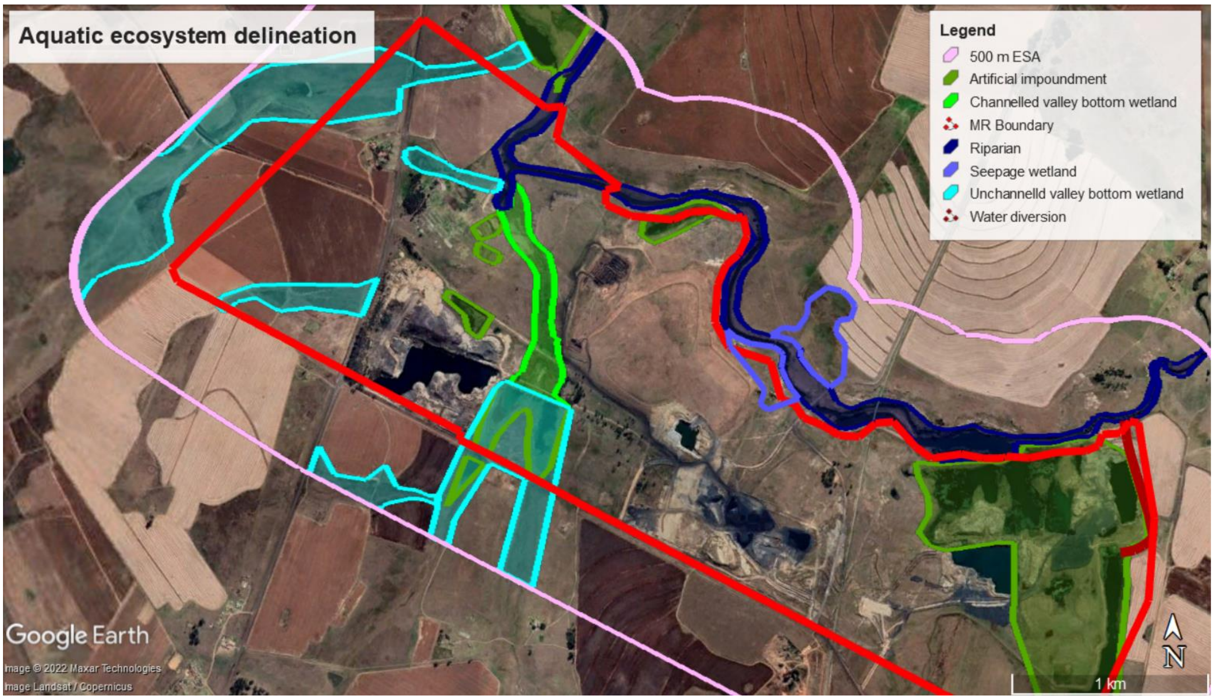

FIGURE 13: AQUATIC ECOSYSTEM DELINEATION

During the site visit of July 2022, mining had commenced along the Olifants River (this activity holds authorisation). A large cut off trench was installed along the Olifants River to ensure overtopping of the banks of the river system cannot occur into the mining works area (Figure 14 and Figure 15).

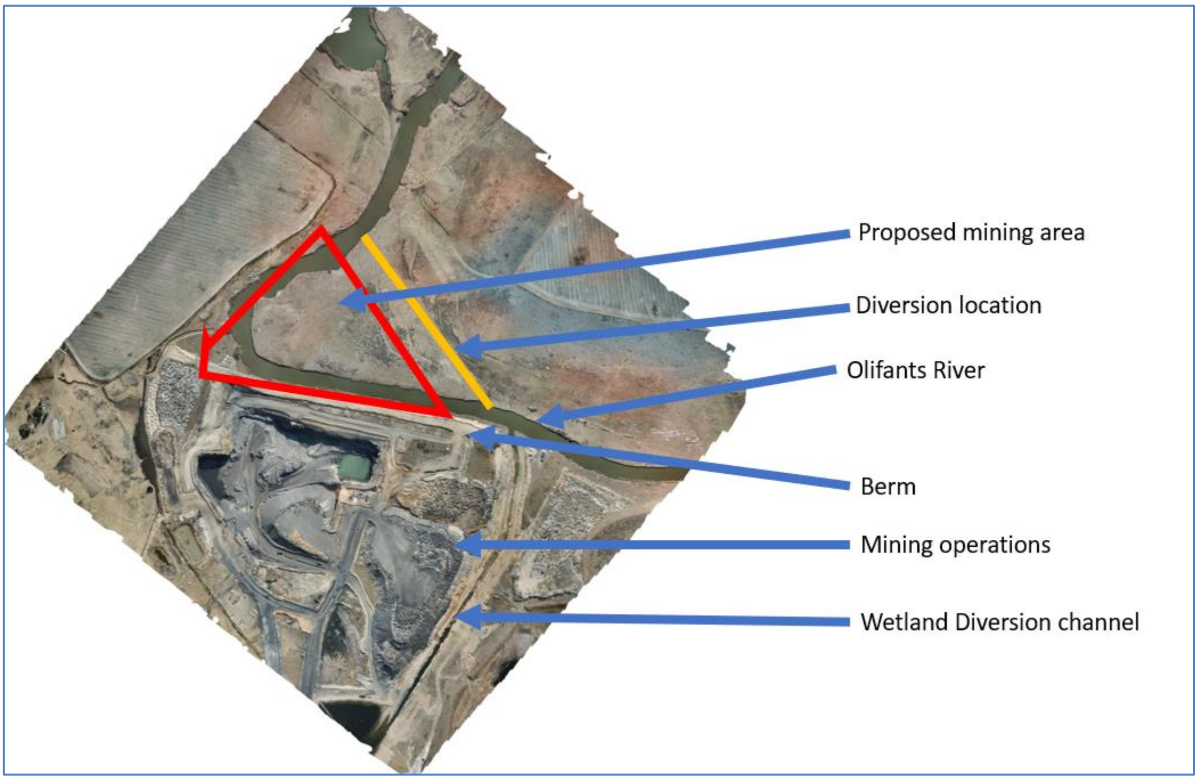

FIGURE 14: 2022 RIVER DIVERSION SITE LAYOUT

FIGURE 15: OLIFANTS RIVER- NOTE EMBANKMENT ON THE LEFT OF THE IMAGE

Historically mining operations to the north of the site holds reference. The "Mistake Lake" is linked to the Olifants River via an inlet and outlet (Figure 16 and Figure 17). This old mining section has been stabilised and rehabilitated after mining operations.

Figure 16: Basic layout of Mistake Lake

Figure 17: Inlet of the Mistake Lake

5.1. Water Quality assessment results

The samples were taken in July 2022 at three main points (**Figure 18**). The samples collected were analysed at a South African National Standards (SANS) approved laboratory (Aquatico Laboratories cc). The Department of Water Affair's Target for Water Quality Range (TWQR) (Department of Water Affairs, 1996) for aquatic ecosystems was used as reference. The results are given in **Table 20** below. Included in the table is the maximum as set by the TWQR (aquatic ecosystems).

FIGURE 18: WATER QUALITY SAMPLE SITE LOCATION

Most of the aspects are within limits. The middle sample site shows a tendency to have elevated results. This can be attributed to the sampling locality in relation to the mining operations or possible unknown aspect at the sample site. The chloride, calcium and potassium results show elevated results- this can possibly be attributed to the regional geology. Increasing elevation in the sulphates is concerning and can indicate possible leaching of impacts from the mining operations. the dissolved salts are also high albeit within range for aquatic ecosystems.

TABLE 20: IN SITU WATER QUALITY TEST RESULTS

Determinants	Units	Upper limit and ranges			Sample locations		
		Aquatic ecosystems					
		TWQR Aquatic ecosystems	CEV	AEV			
		(Ideal)	(Chronic effect value)	(Acute effect value)	**Onder**	**Middel**	**Bo**
Conductivity at 25 ^{0}C	mS/m	70	150	370	43,2	65,3	65,8
Dissolved solids	mg/l	450	1 000	2 400	264	401	419
pH value at 25 ^{0}C	pH units	6,0-9,0	5,0-9,5	4,0-10,0	8,43	7,95	7,88
Suspended solids (Total)	mg/l	<100	>100		39	50	15
Alkalinity	caco3/l	Slightly hard 100 to 150			104	158	150
Calcium as Ca	mg/l	NA			29,8	45,9	48,3
Chloride as Cl	mg/l	0,2	0,35	5	26,2	44,2	43,9
Fluoride as F	mg/l	0.75	1.5	2.54	-0,263	0,263	-0,263
Magnesium as Mg	mg/l	NA			19,8	31,4	33,3
Nitrate and nitrite as N	mg/l	NA			0,213	-0,194	0,197
Potassium as K	mg/l	NA			7,05	7,78	7,83
Sulphate as SO_4	mg/l	NA			91	136	155
Aluminium as Al with pH > 6,5	mg/l	0,01	0,02	0,15	-0,002	0,026	-0,002
Iron as Fe	µg/l	NA			-0,004	-0,004	-0,004
Manganese as Mn	mg/l	0.18	0.37	1.3	-0,001	-0,001	-0,001

5.1.1.Olifants River system of the study site

The Olifants River is deep (>1.5 meters) with steep banks and a narrow marginal zone on site. The active channel in the system is wide, with *Salix mucronata* in places on the edge of the banks (Figure 20).

FIGURE 19: THE OLIFANTS RIVER RIPARIAN AREA OF THE LARGER STUDY SITE

FIGURE 20: A TYPICAL IMAGE OF THE OLIFANTS RIVER ON SITE

5.1.1.1. Aquatic ecosystem classification (Ollis *et al* 2013)

The classification of the aquatic system was done using the dichotomous key in Ollis *et al.* (2013) (**Table 21**) with the services provided by the aquatic ecosystems found on site in Table 5.

TABLE 21: SUMMARY OF THE APPLICATION OF LEVELS 1 TO 5 OF THE AQUATIC ECOSYSTEM CLASSIFICATION IN ACCORDANCE WITH THE DICHOTOMOUS KEY FROM OLLIS *ET AL.* 2013

Watercourse	**Level 3**		**Level 4:** HGM Unit			**Level 5**				
	Key 1 Landscape Unit		**Key 2**			**Key 3a** River Flow types		**Key 3b** Hydroperiod		
	Level 3a	**Level 3b**	**Level 4a** HGM Type	**Level 4b**	**Level 4c**	**Level 5a**	**Level 5b**	**Level 5 a** Inundation period	**Level 5b** Saturation period	**Level 5 c** Inundation depth class
Riparian area	Valley floor (no 5)	N/A	River			Perennial	Seasonal	Permanent	Permanently saturated	Limnetic

5.1.1.2. PES of the systems

Using the method described above, the following calculations were completed to determine the Present Ecological Score (PES) of the aquatic ecosystem found on site. See Table 22 for the PES calculation.

Table 22: The Wetland IHI PES result of the wetland system

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	**Weighting**	**Score**	***Confidence Rating***	**PES Category**
DRIVING PROCESSES:		**100**	**1,9**		
Hydrology	1	80	2,4	*4,0*	**D**
Geomorphology	2	100	1,6	*4,0*	**C**
Water Quality	3	30	2,1	*4,2*	**D**
WETLAND LANDUSE ACTIVITIES:		**100**	**1,5**	***4,0***	
Vegetation Alteration Score	1	100	1,5	*4,0*	**C**
Weighting needs to consider the sensitivity of the type of wetland *e.g.: nutrient poor wetlands are sensitive to nutrient loading (Water Quality rated higher)*					
OVERALL SCORE:			**1,7**	***Confidence Rating***	
	PES %		**65,6**		
	PES Category:		**C**	***2,0***	

The PES score of the system indicated the system to be **Moderately modified "A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact**".

5.1.1.3. Ecological Importance and Sensitivity

EIS was calculated in Table 23. The REMC was calculated to be in ***High*** condition "Aquatic ecosystems that are ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers".

Table 23: The EIS score of the seepage wetlands and REMC classification (0 indicates no importance and 4 indicates very high importance)

Determinant **PRIMARY DETERMINANTS**	**Score**	**Confidence**	**Discussion**
Rare & Endangered Species	3	3	Possibility of Marsh Sylph (*Metisella meninx*) in the system. Other endangered species of fauna are also possible in the system.
Populations of Unique Species	3	4	The system has varied habitat in the main channel as well as in the marginal zones of the system for unique species.
Species/taxon Richness	2	3	Diverse
Diversity of Habitat Types or Features	3	2	Diverse fauna and flora
Migration route/breeding and feeding site for wetland species	3	2	Highly important water sources and movement corridor
Sensitivity to Changes in the Natural Hydrological Regime	1	3	The system is a high-volume low velocity river system, of second stream order. The system can buffer many of the impacts, but overall accumulation will show in the system over time.
Sensitivity to Water Quality Changes	1	3	
Flood Storage, Energy Dissipation & Particulate/Element Removal	3	2	

MODIFYING DETERMINANTS			
Protected Status	3	3	Although not formally protected, the risk of flooding is high in the system and thus the system is protected.
Ecological Integrity	2	3	The system is ecologically intact although many impacts have occurred on the system.
TOTAL	24		
MEAN (Total / 10)	2.4		
Recommended Ecological Management class (REMC)	**High**		

5.1.2. Artificial impoundments

Many artificial impoundments were observed on site (Figure 21). Many of these are associated with old mining and farming activities. The impoundments to the west of the site are of low concern. The eastern impoundment is difficult to assess, as this was a channelled valley bottom system. Mining activities has completely transformed the system and the functions and composition of the old valley bottom wetland have been lost. A diversion channel moves water entering the system from the south (an unchannelled valley bottom system) around the impacted area. The impoundment area is also very high in salts - as associated with mining activities and acid mine drainage (AMD). The main ecological function of this system is the attenuation of water and the provision of open standing water habitat (for especially the Marsh sylph butterfly).

FIGURE 21: THE LOCATION OF THE ARTIFICIAL IMPOUNDMENTS – NOTE THE DIVERSION CHANNEL TO THE EAST.

5.1.2.1. Aquatic ecosystem classification (Ollis *et al* 2013)

The classification of the Ollis et al does not make provision for artificial systems (Ollis *et al* 2013).

5.1.2.2. Ecological Importance and Sensitivity

The EIS calculation for the artificial impoundments on site could not be done due to the artificial nature of these systems.

5.1.3.Channelled valley bottom wetland

A single channelled valley bottom wetland was observed on site (Figure 22). The system feeds directly into the Olifants River and is fed from an unchannelled valley bottom wetland (see section 5.1.11 below). The system is relatively flat, and it was observed that the Olifants River pushes back into the system to create a floodplain area. The system is impacted by grazing. The unchannelled valley bottom wetland feeding into the system is impacted by impoundments. This directly influences the hydrology of the channelled valley bottom wetland.

FIGURE 22: THE LOCATION OF THE CHANNELLED VALLEY BOTTOM WETLAND ON SITE

5.1.4. Aquatic ecosystem classification (Ollis *et al* 2013)

The classification of the system was done using the dichotomous key in Ollis *et al.* (2013) (Table 24) with the services provided by the aquatic ecosystems found on site in Table 5.

TABLE 24: SUMMARY OF THE APPLICATION OF LEVELS 1 TO 5 OF THE AQUATIC ECOSYSTEM CLASSIFICATION IN ACCORDANCE WITH THE DICHOTOMOUS KEY FROM OLLIS *ET AL.* 2013

	Level 3		**Level 4:** HGM Unit			**Level 5**				
	Key 1 Landscape Unit		**Key 2**			**Key 3a** River Flow types		**Key 3b** Hydroperiod		
Watercourse	**Level 3a**	**Level 3b**	**Level 4a** HGM Type	**Level 4b** River zonation	**Level 4c** River Flow type	**Level 5a**	**Level 5b**	**Level 5 a** Inundation period	**Level 5b** Saturation period	**Level 5 c** Inundation depth class
Channelled valley bottom wetland	Valley floor (no 5)		Channelled valley bottom					Intermittently inundated	**Seasonal saturated**	Limnetic

5.1.5.PES of the systems

Using the method described above, the following calculations were completed to determine the Present Ecological Score (PES) of the aquatic ecosystem found on site. See Table 25 for the PES calculation.

TABLE 25: THE WETLAND IHI PES RESULT OF THE WETLAND SYSTEM

OVERALL PRESENT ECOLOGICAL STATE (PES) SCORE					
	Ranking	**Weighting**	**Score**	***Confidence Rating***	**PES Category**
DRIVING PROCESSES:		**100**	**2,2**		
Hydrology	1	80	3,1	*3,8*	**D/E**
Geomorphology	2	100	1,6	*4,0*	**C**
Water Quality	3	30	1,9	*4,4*	**C**
WETLAND LANDUSE ACTIVITIES:		**100**	**2,4**	***4,0***	
Vegetation Alteration Score	1	100	2,4	*4,0*	**D**
Weighting needs to consider the sensitivity of the type of wetland *e.g.: nutrient poor wetlands are sensitive to nutrient loading (Water Quality rated higher)*					
OVERALL SCORE:			**2,3**	***Confidence Rating***	
	PES %		**54,6**		
	PES Category:		**D**	***2,0***	

The PES score of the system indicated the system to be **largely modified** "A large change in ecosystem processes and loss of natural habitat and biota and has occurred". The PES score is primarily driven by the large artificial impoundment found on site. The hydrology of the system is highly impacted by the impoundment. Of concern is the release of water from the dam back into the wetland, with channelization forming below the dam wall. The geomorphology is also impacted by the impoundment.

5.1.6.Ecological Importance and Sensitivity

EIS was calculated in Table 26. The REMC was calculated to be in ***Moderate*** condition "Aquatic ecosystems that are ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers".

TABLE 26: THE EIS SCORE OF THE SEEPAGE WETLANDS AND REMC CLASSIFICATION (0 INDICATES NO IMPORTANCE AND 4 INDICATES VERY HIGH IMPORTANCE)

Determinant	Score	Confidence	Discussion
PRIMARY DETERMINANTS			
Rare & Endangered Species	2	3	Possible but highly unlikely due to the lack of cover in the system. If water is present in the channel of the wetland, the EIS score will improve. The vegetation in the system was also very short during the site visit, reducing functional habitat. There is however a possibility of the Marsh Sylph (*Metisella meninx*) butterfly in the system.
Populations of Unique Species	1	4	
Species/taxon Richness	2	3	
Diversity of Habitat Types or Features	2	2	
Migration route/breeding and feeding site for wetland species	2	2	The wetland provides a corridor for movement from the wetlands to the Olifants River.
Sensitivity to Changes in the Natural Hydrological Regime	2	3	Highly important as the wetland is a buffer between the wetland and the Olifants River.
Sensitivity to Water Quality Changes	2	3	
Flood Storage, Energy Dissipation & Particulate/Element Removal	3	2	
MODIFYING DETERMINANTS			
Protected Status	1	3	Not protected and highly affected and utilised.
Ecological Integrity	2	3	Remains intact although the wetland is highly impacted and degraded
TOTAL	19		
MEAN (Total / 10)	1.9		
Recommended Ecological Management class (REMC)	**Moderate**		

5.1.7.Seepage wetlands

The seepage wetlands of the study site are located adjacent to and feeding directly into the Olifants River (Figure 23). The system to the south seems to have been created by the old mine tailings, but details on the 1954 image shows some indications of the system being present pre mining activities (Figure 23).

FIGURE 23: THE SEEPAGE WETLANDS OF THE STUDY SITE

5.1.8.Aquatic ecosystem classification (Ollis et al 2013)

The classification of the system was done using the dichotomous key in Ollis *et al.* (2013) (Table 28) with the services provided by the aquatic ecosystems found on site in Table 5.

5.1.9.PES of the systems

Using the method described above, the following calculations were completed to determine the Present Ecological Score (PES) of the aquatic ecosystem found on site. See Table 27 for the PES calculation.

TABLE 27: THE WETHEALTH PES RESULT OF THE WETLAND SYSTEM

	Northern Seepage wetland		**Southern seepage wetland**	
Geomorphology	**C**	Impacted by cultivation in the catchment of the system.	**E**	Highly impacted by the mine tailings on top of the wetland

Hydrology	**B**	Natural, somewhat reduced function by the cultivation of the system	**E**	
Vegetation	**B**	More natural, with varying species of hydrophytes.	**C**	Degraded and reduced to homogenous stands of *Imperata cylindrica* and *Typha capensis*.
PES	**B** 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.		**E** The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable	

5.1.10. Ecological Importance and Sensitivity

A combined EIS was calculated in Table 29. The REMC was calculated to be in ***Moderate*** condition "Aquatic ecosystems that are ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers".

TABLE 28: SUMMARY OF THE APPLICATION OF LEVELS 1 TO 5 OF THE AQUATIC ECOSYSTEM CLASSIFICATION IN ACCORDANCE WITH THE DICHOTOMOUS KEY FROM OLLIS *ET AL.* 2013

Watercourse	**Level 3**		**Level 4:** HGM Unit			**Level 5**				
	Key 1 Landscape Unit		**Key 2**			**Key 3a** River Flow types		**Key 3b** Hydroperiod		
	Level 3a	**Level 3b**	**Level 4a** HGM Type	**Level 4b** River zonation/	**Level 4c** River Flow type	**Level 5a**	**Level 5b**	**Level 5 a** Inundation period	**Level 5b** Saturation period	**Level 5 c** Inundation depth class
Seepage wetland	Hilltop (No 1)	Saddle	Seep	Without channeled outflow				Never/ Rarely inundated	Permanently saturated	Limnetic

TABLE 29: THE EIS SCORE OF THE SEEPAGE WETLANDS AND REMC CLASSIFICATION

Determinant	**Score**	**Confidence**	**Discussion**
PRIMARY DETERMINANTS			
Rare & Endangered Species	2	3	Possibility of Marsh Sylph (*Metisella meninx*) butterfly in the system.
Populations of Unique Species	2	4	
Species/taxon Richness	1	3	Low, limited to flora
Diversity of Habitat Types or Features	1	2	Limited due to low variation of habitat
Migration route/breeding and feeding site for wetland species	1	2	Low due to type of system and limited links to other aquatic systems outside that of the Olifants River system
Sensitivity to Changes in the Natural Hydrological Regime	3	3	See **Table 2** above
Sensitivity to Water Quality Changes	2	3	
Flood Storage, Energy Dissipation & Particulate/Element Removal	1	2	
MODIFYING DETERMINANTS			
Protected Status	0	3	Not protected and highly impacted
Ecological Integrity	2	3	Somewhat still functional but ecology is fragmented
TOTAL	15		
MEAN (Total / 10)	1.5		
Recommended Ecological Management class (REMC)	**Moderate**		

5.1.11. Unchannelled valley bottom wetland

Various areas of unchannelled valley bottom wetlands were observed on site (Figure 24). All these feed into the Olifants River, either directly or through another aquatic ecosystem. Most of the system is degraded due to historical mining and cultivation in the catchment of the system. Almost all the systems are impounded (Figure 25).

FIGURE 24: UNCHANNELLED VALLEY BOTTOM WETLANDS OF THE STUDY AREA.

FIGURE 25: IMPOUNDMENTS OF THE UNCHANNELLED VALLEY BOTTOM WETLANDS

5.1.11.1. Aquatic ecosystem classification (Ollis et al 2013)

The classification of the system was done using the dichotomous key in Ollis *et al.* (2013) (Table 30) with the services provided by the aquatic ecosystems found on site in Table 5.

5.1.11.2. PES of the systems

Using the method described above, the following calculations were completed to determine the Present Ecological Score (PES) of the aquatic ecosystems found on site. See Table 31 for the PES calculation.

TABLE 30: SUMMARY OF THE APPLICATION OF LEVELS 1 TO 5 OF THE AQUATIC ECOSYSTEM CLASSIFICATION IN ACCORDANCE WITH THE DICHOTOMOUS KEY FROM OLLIS *ET AL.* 2013

Watercourse	**Level 3**		**Level 4:** HGM Unit			**Level 5**				
	Key 1 Landscape Unit		**Key 2**			**Key 3a** River Flow types		**Key 3b** Hydroperiod		
	Level 3a	**Level 3b**	**Level 4a** HGM Type	**Level 4b** River zonation	**Level 4c** River Flow type	**Level 5a**	**Level 5b**	**Level 5 a** Inundation period	**Level 5b** Saturation period	**Level 5 c** Inundation depth class
Unchannelled valley bottom wetland	Valley floor		Unchannelled valley bottom					**Never/ Rarely inundated**	**Seasonal saturated**	Limnetic

TABLE 31: THE WETHEALTH PES RESULT OF THE WETLAND SYSTEM

	GEOMORPHOLOGY	HYDROLOGY	VEGETATION	PES
A	C	B	A	B
	Impacted by road crossing and mining in the upper reaches of the system	Mostly intact with only a road crossing of the system impacting the hydrology	Diverse and natural	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.
B	C	C	B	C
	Affected by cultivation in the catchment as well as mining. The system is also impounded. Various branches of wetland feeds into the system, creating an ever-larger wetland	Impounded with signs of abstraction	Affected by grazing and grass cutting. Vegetation was short during the site visit.	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact
C	D	E	B	D
	The system ends abruptly in the current mining activity on site.		Low diversity, cut/grazed short	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.
D	D	D	A	C
	Impacted by the road crossing of the system as well as various small impoundments		Diverse vegetation with good coverage	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact
E	C	C	C	C
	Some impoundments and road crossings reduce the geomorphology of the system	Road crossings and impoundments in small scale reduces the hydrological connectivity of the system	Affected by grazing and grass harvesting. Low diversity	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact

5.1.12. Ecological Importance and Sensitivity

The EIS results for the unchannelled valley bottom wetlands are given in Table 32. The calculations were not included in the report to save printing volumes. The possibility of Marsh Sylph (*Metisella meninx*) in the system increases the rare and endangered species probability in all these systems.

TABLE 32: SUMMARY OF THE EIS AND REMC FOR THE UNCHANNELLED VALLEY BOTTOM WETLANDS

<table>
<tr><th></th><th>EIS Score</th><th>REMC</th><th></th></tr>
<tr><td>A</td><td>2.3</td><td>High</td><td rowspan="2">Aquatic ecosystems that are ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.</td></tr>
<tr><td>B</td><td>2.1</td><td>High</td></tr>
<tr><td>C</td><td>1.2</td><td>Moderate</td><td rowspan="2">Aquatic ecosystems that are ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.</td></tr>
<tr><td>D</td><td>1.5</td><td>Moderate</td></tr>
<tr><td>E</td><td>2.4</td><td>High</td><td>Aquatic ecosystems that are ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.</td></tr>
</table>

5.2. River diversion assessment

5.2.1.Bathometric analysis results

Using the Deeper Pro, analysis was completed in a 2.5hp inflatable boat. Speed was regulated to 4-5 km/h to ensure consistency. The sample runs were completed twice to ensure accuracy. The average depth of the river at the diversion section was 2.9 meters. This is deep and indicates the water flow to be slow and deep as in line with SASS 5 (Dickens and Graham, 2002) descriptions. A larger section of the river was assessed to increase hydrological driver awareness for the system (Figure 26).

The diversion area is shown in Figure 27. Near the bend in the system a section of the water is as deep as 8 meters. This was verified using a Secchi disk depth gauge (Chapman, 1996) (Figure 28) (Department of Water and Sanitation, 2016). The proposed inlet section of the diversion is given in Figure 29. This section is very uniform without any major depth variations. This is possibly due to the water hydrology not being turbulent, due to bends in the systems or other water sources (wetlands etc) entering the section here.

It is important to note that bathometric deviations form habitat for ichthyofauna. The Deeper sonar is commercially sold as a fish finder, and the application thereof as a bathometric analysis device is secondary. During the assessment, it was noted that after depth deviations, large fish was observed by the sonar. This shows increased habitat suitability by the deviations in the system for fish. It is important to note that two sections of weirs or artificial impoundments is located at -26.153888° 29.344718° and -26.156995° 29.341676°. This alters the hydrology habitat of the system by slowing water flow, settling sediments, and increasing unnatural species composition of fauna and flora.

FIGURE 26: THE BATHOMETRIC ASSESSMENT RESULTS FOR THE STUDY SITE

FIGURE 27: BATHOMETRIC RESULTS FOR THE DIVERSION AREA

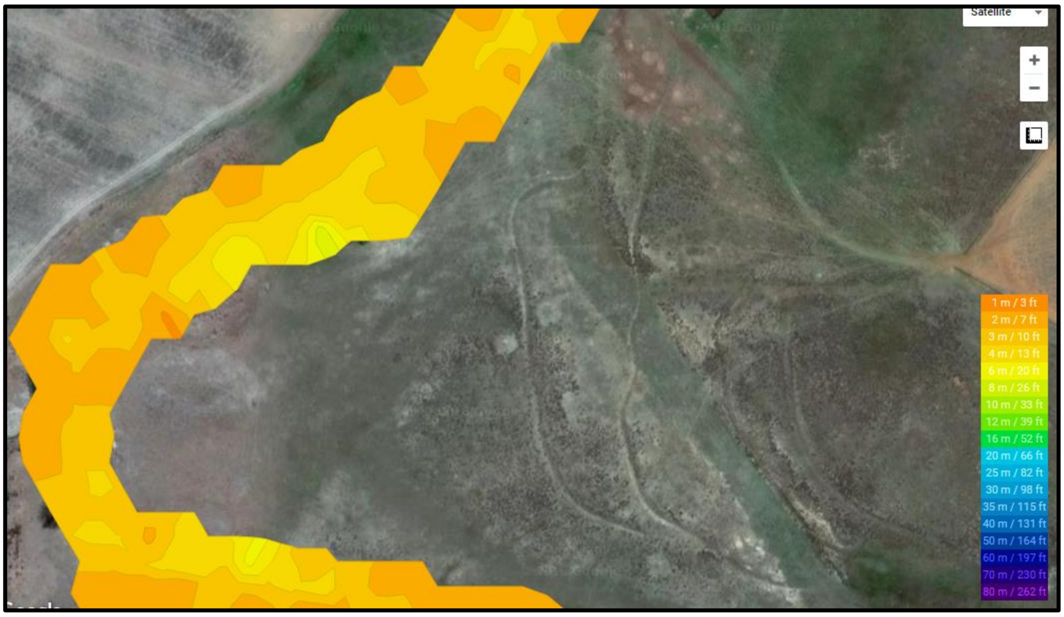

FIGURE 28: BATHOMETRIC RESULTS FOR THE LOWER POINT OF THE DIVERSION

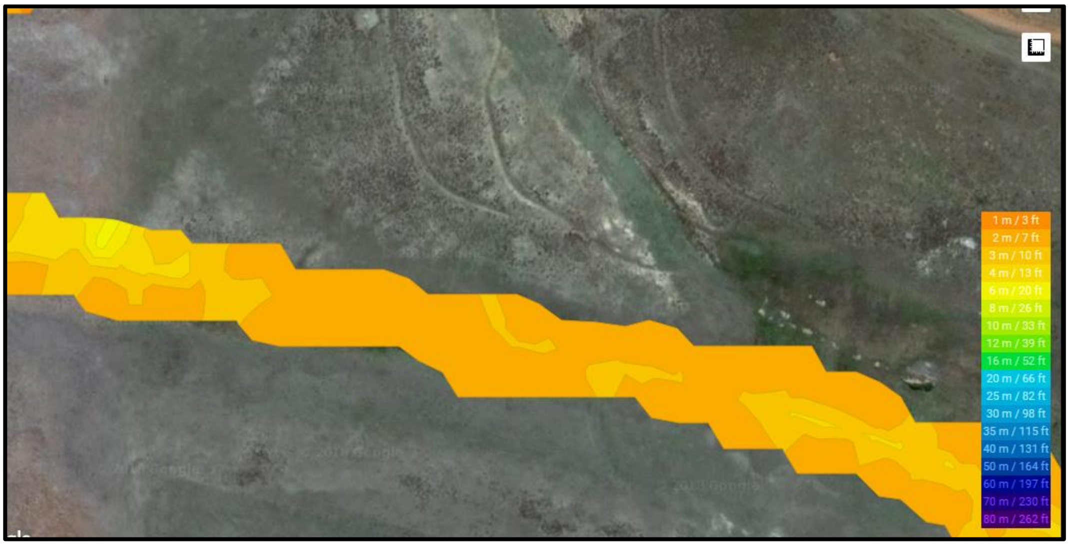

FIGURE 29: BATHOMETRIC RESULTS FOR THE UPPER POINT OR INLET OF THE DIVERSION

5.2.2.Bank morphology

In 2018 the assessment of the banks of the Olifants River system was undertaken to assess the shape and form of the banks of the area before the diversion. The morphology of the banks was assessed at 15 points, located throughout the bend (Figure 30). In 2022, the southern samples points of Launch1, 001, 002, 003and 007 has been altered by the berm. Historical data is retained in terms of the value of historical data.

These points were chosen as they varied from the norm. This was specifically done to assess varying habitat. Due to the difficulty of assessing varying slope and access issues, the vertical height (from water level to upper base) was calculated. The distance from the upper marginal end was measured to the edge of the water. This was used to calculate the slope of the bank in degrees. See Figure 31 for a simplified sketch of the method applied and Table 33 for the results.

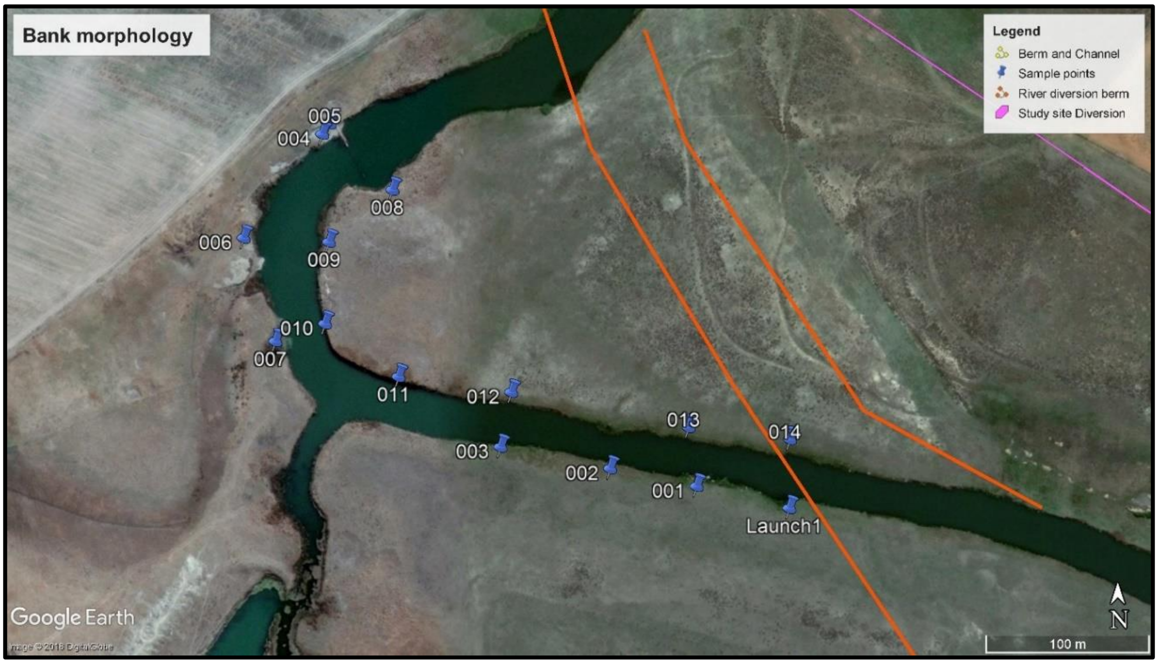

FIGURE 30: BANK MORPHOLOGY SAMPLE SITES

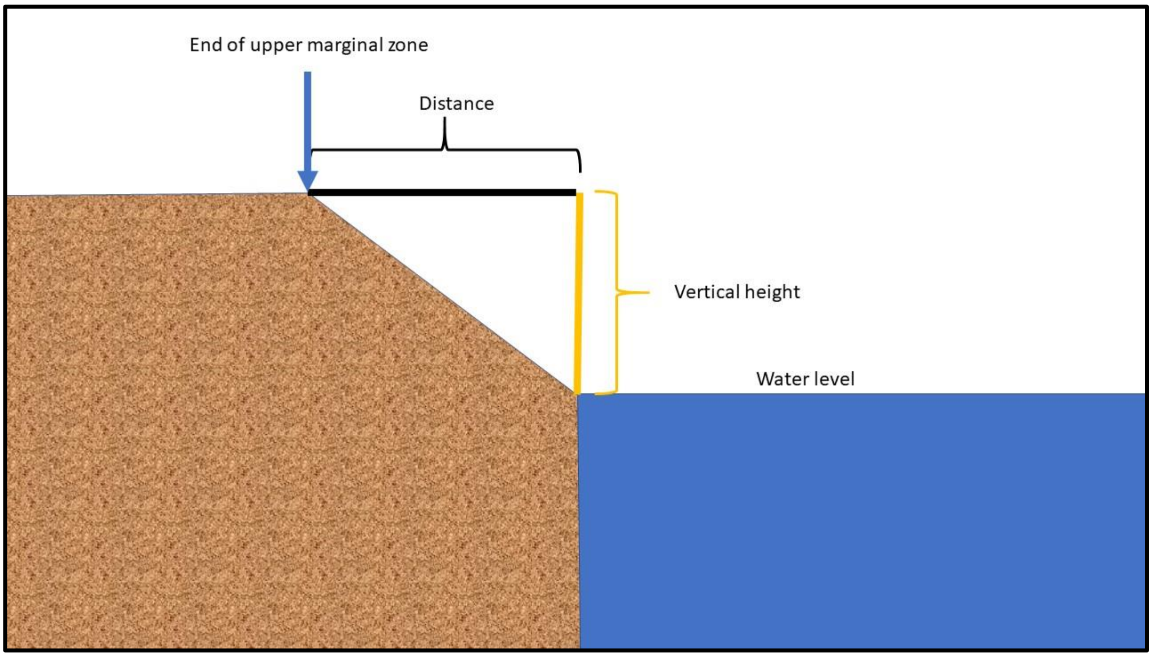

FIGURE 31: SIMPLE SLOPE CALCULATION METHOD

TABLE 33: THE BANK MORPHOLOGY RESULTS FOR THE SAMPLE SITES

Site no	oppisite	adjacent		
	Vertical bank height	Distance	Slope length	bank slope (degrees)
Lunch Site	76	570	575	8
1	127	475	492	15
2	81	320	330	14
3	74	270	280	15
4	50	235	240	12
5	153	450	475	19
6	130	390	411	18
7	147	315	348	25
8	195	370	418	28
9	204	295	359	35
10	163	301	342	28
11	149	200	249	37
12	155	301	339	27
13	95	320	334	17
14	105	390	404	15

Using the guide (Dallas, 2005) the assessment of the channels and banks was completed per site. See Table 34 for the sample site's channel feature descriptions.

TABLE 34: CHANNEL FEATURE DESCRIPTION PER SITE

Site number	Dallas (2005) description
Launch	Flood bench (inundated by annual flood)
1	Terrace (infrequently inundated)
2	
3	Flood bench (inundated by annual flood)
4	
5	Terrace (infrequently inundated)
6	
7	
8	High terrace (rarely inundated)
9	
10	
11	
12	
13	Terrace (infrequently inundated)
14	Flood bench (inundated by annual flood)

5.2.2.1. Channel size

The channel width was measured at the same sites as the bank morphology sites (Figure 30). The sites were placed across from one another and thus on values for lunch site to 7 is given in Table 35. An average active channel of 29 meters was calculated.

TABLE 35: ACTIVE CHANNEL WIDTH MEASURED IN METERS

	Width of active channel in meters	Average width of the active channel
Lunch Site	23	
1	22	
2	21	
3	26	
4	28	
5	46	
6	39	
7	26	29
8	46	
9	39	
10	26	
11	25	
12	26	
13	22	
14	23	

5.2.3. Biotic reagents assessment

Biotic assessments were completed for the project based on the methods described above. As the diversion will have a permanent impact, the main aim of the assessments was to provide baseline information and provide measurable goals for monitoring. The results will also be used to infer information of the rehabilitation of the diversion channel in terms of habitat creation.

5.2.3.1. SASS 5

Five sample sites for SASS 5 protocol were used for the project in 2018 and 2022. It clearly states in the methodology of the SASS 5 method that SASS can realistically only be applied in a water column of 1.5 meters or less (Dickens and Graham, 2002). This was emulated in Barbour *et al.*, (1998). In the case of the study site, the depth of the water exceeds this. Care must be taken when applying SASS 5 to deep systems, as the required habitats is not present. It was for this reason that a full SASS 5 assessment could not be completed for the study site.

The aim of the project is to infer results from the *in-situ* conditions and recommend future mitigation and rehabilitation measures. The assessment of benthic aquatic macroinvertebrates reverted to assessing habitat requirements based on presence. As benthic soil structure cannot be predetermined, the assessments were based on aquatic flora presence, connected to aquatic macroinvertebrate presence. This will allow the guidance of aquatic flora for rehabilitation requirements.

FIGURE 32: SASS 5 SAMPLE SITE LOCATION

A total of 21 taxa was observed in the five sample sites. These include: Hirundea, Atyidae, Hydracarina, Baetiedae (>2 sp), Tricorythidae, Coegnagrionidae, Lestidae, Belostomatidae, Gerridae, Naucoridae, Nepidae, Notonectidae, Pleidae, Vellidae, Hydropsychidae (sp1), Hydroptilidae, Dytisicidae, Ceratopogonidae, Chironomidae, Physidae, Unionidae, and notably Daphnia. Daphnia occurs in deep water that is slow moving and is usually an indicator that SASS 5 protocol must be attempted with care, due to habitat requirements outside the scope of the protocol. The results are given in Table 36.

TABLE 36: COMPARATIVE SASS 5 RESULTS FROM 2018 VS 2022

	SASS SCORE	Site 1		Site 2		Site 3		Site 4		Site 5	
		2018	2022	2018	2022	2018	2022	2018	2022	2018	2022
Hirundea	3	1	A								
Atyidae	8	B	A	B	A	A	A		A	A	A
Hydracarina	8	A	A	B		B	A	A		A	
Baetidae 1 sp	4		B		B		A				A
Baetidae 2 sp	6	B				B		A	B	B	
Baetiedae>2 sp	12			B							
Tricorythidae	9	A		A							
Coegnagrionidae	4	A	A	A	A		B	A	A	A	B
Lestidae	8	A	A	A		A	1	1	A	1	A
Belostomatidae	3		1	A		A	B	A		A	1
Gerridae	5	B				A		1		1	
Naucoridae	7	A	1	1		A	1		A		A
Nepidae	3					1			1		
Notonectidae	3	A	A		1	B	A	B	B	B	B
Pleidae	4	A		1		B		A		B	
Vellidae	5		A	A			A	A	A	A	
Hydropsychidae sp1	4	A	A	B	A	A	B	A	A	A	A
Hydroptilidae	6			1							
Dytisicidae	5	A		B		A		A		A	
Ceratopogonidae	5	1	A	1	A	A	A	A	B	A	A
Chironomidae	2	B	A	B	A	1	A	1	A	1	A
Physidae	3	A	A								
Unionidae	6	A					1				
SASS score		94	67	96	40	75	67	66	56	74	48
Number of taxa		18	14	16	7	15	13	14	12	15	10
ASPT		5,2	4,8	6,0	5,7	5,0	5,2	4,7	4,7	4,9	4,8
Daphnia		*A*	*B*	*A*	*A*		*A*				

The average score per taxon (ASPT) of the samples sites was 5.2 in 2018 and in 2022 this was 5.0. This indicates the sample sites to be very similar in composition, but a slight decrease has occurred in the four years. This is suspected to be more seasonal driven than impact or degradation of water habitat. Daphnia was encountered at three of the five sites, showing the water movement to be very slow throughout the sites. See Figure 33 for a graph of the ASPT results of 2018 and 2022 over the various sample sites.

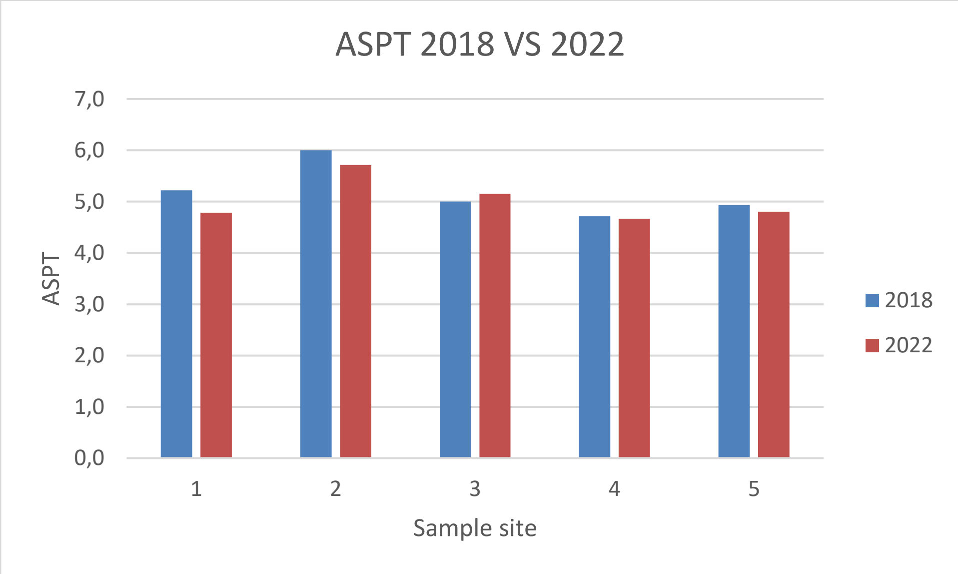

FIGURE 33: GRAPH OF THE 2018 VS 2022 ASPT RESULTS

5.2.3.2. Fish population assessment

Fish habitat abundance assessment was completed for the study site and is presented in Table 37. Due to the depth of the water on site, standard methods (electrofishing) did not produce fish in the water column. This immediately removes many of the *Barbus* species or *Enteromius sp.* (Skelton, 2016) as they prefer shallow/deep fast-moving water (Kleynhans and Mackenzie, 2007). Cast-netting using a 5-meter diameter net from the inflatable boat also did not produce any fish. Sampling of the banks for the aquatic macroinvertebrates did however produce some fish. These were limited to *Gambusia affinis* and *Tilapia sparrmanii*. *Clarias gariepinus* was observed feeding in the marginal vegetation. *Cyprinus carpio* is known to be actively caught in the system. All these species can move and adapt to new habitat and impacts to these species by the diversion is expected to be minimal.

TABLE 37: FISH HABITAT ASSESSMENT RESULTS
(0- absent, 1- rare, 2- sparse, 3- common, 4 – abundant, 5- very abundant)

	Slow deep	Slow shallow	Fast deep	Fast shallow
Overhanging vegetation	2	2	0	0
Undercut banks and root wads	4	2	0	0
Substrate	3	2	0	0
Aquatic macrophytes Water column	3	2	0	0
Mean	**3**	**2**	**0**	**0**

5.2.3.3. Vegetation community composition

In 2018 during the assessment of the river bank morphology, vegetation species composition was included to indicate varying habitat provided by the bank morphology (Figure 34). The 2022 sample was completed during the winter month and most of the vegetation aspects were either dormant or difficult to identify. The 2018 results are presented below for reference in terms of the impact assessment of the proposed diversion. Lauch01, 001, 002, 003 and 007 does not have the same relevance as in 2018 and is included for rehabilitation reference.

To assess the vegetation community structure in the system, the identification of the species was included in the bank morphology as described above (section 5.2.2 on page 58). To illustrate the vegetation communities, simple side view drawings was created for the sample sites. Species encountered in the marginal zones include: *Cynodon dactylon, Cyperus articulatus, Eragrostis curvula, Gomphostigma virgatum, Hyparrhenia hirta, Juncus articulatus, Juncus effesus, Leersia hexandra, Panicum natalensis, Paspalum scrobiculatum, Phragmites australis, Phragmites capensis, Persicaria lapathifolia, Pycreus polystachyos, Rorippa nudiuscula, Salix babylonica, Themeda triandra, Typha capensis* and *Verbena bonariensis.*

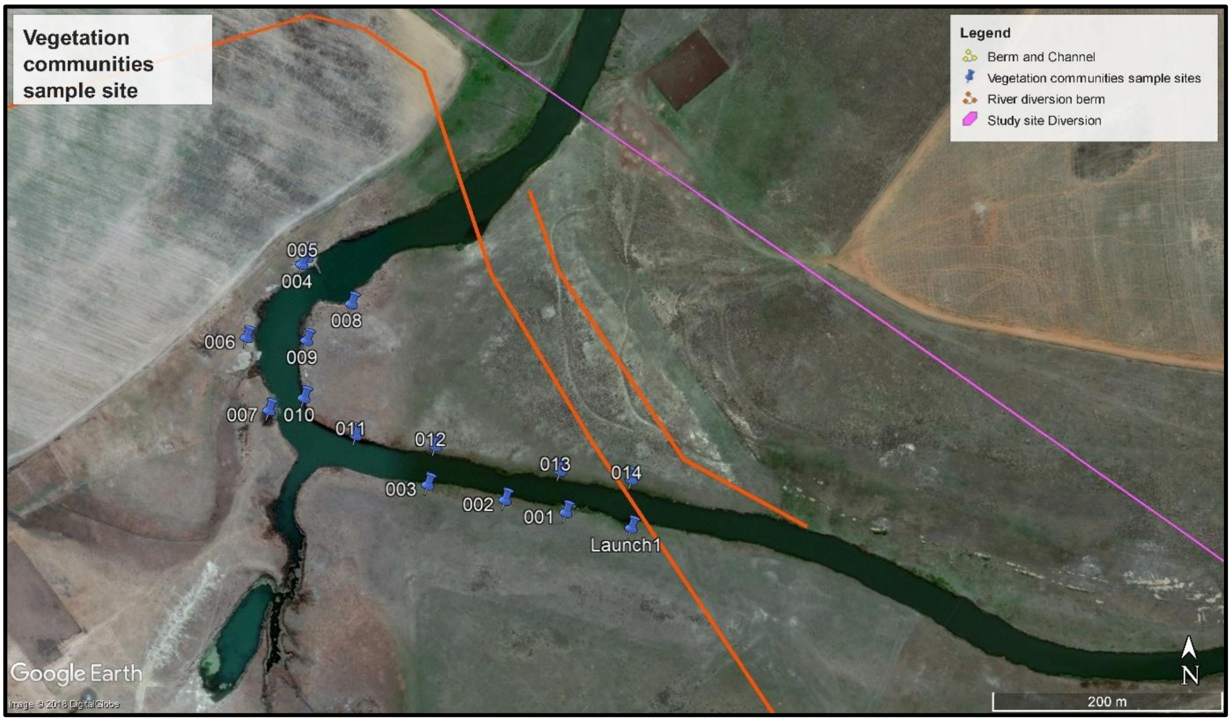

FIGURE 34: LOCATIONS FOR VEGETATION COMMUNITY SAMPLE SITES

See Figure 35 to Figure 49 for the species composition based on bank morphology.

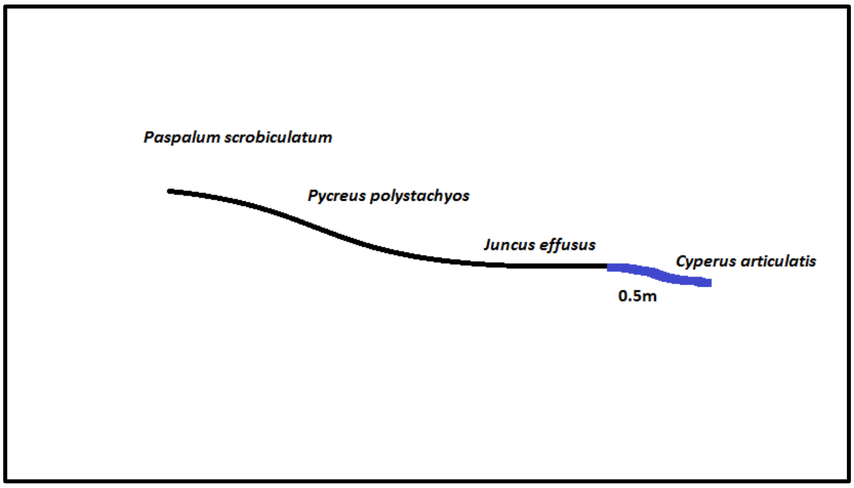

FIGURE 35: LAUNCH SITE VEGETATION COMMUNITY COMPOSITION

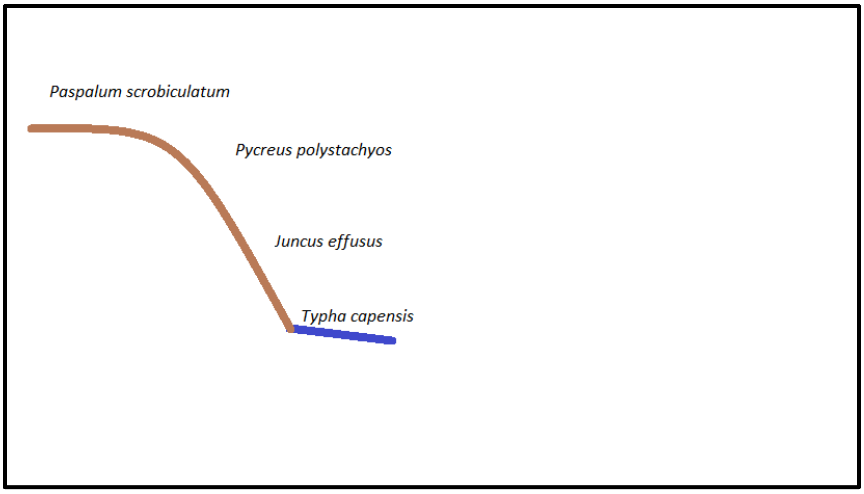

FIGURE 36: 001 VEGETATION COMMUNITY COMPOSITION

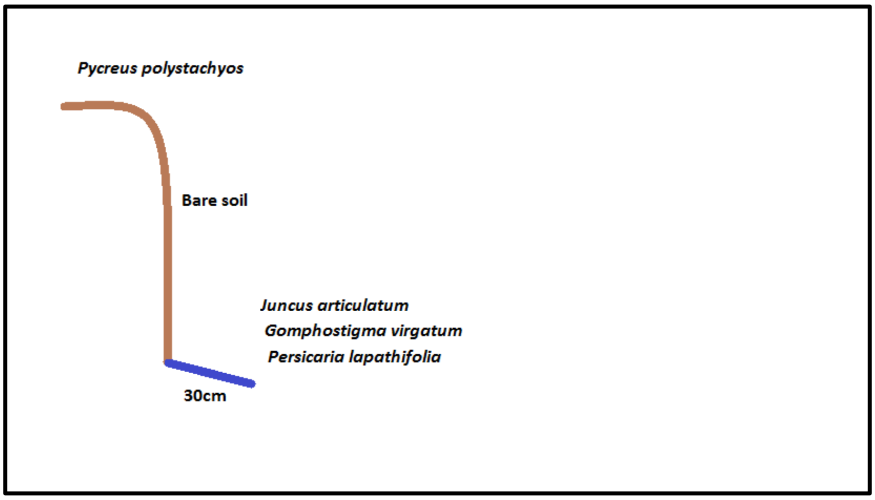

FIGURE 37: 002 VEGETATION COMMUNITY COMPOSITION

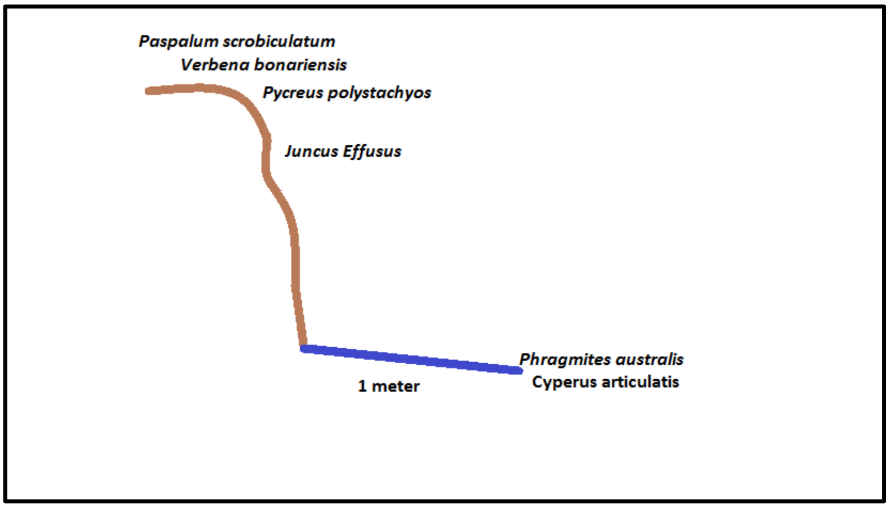

FIGURE 38: 003 VEGETATION COMMUNITY COMPOSITION

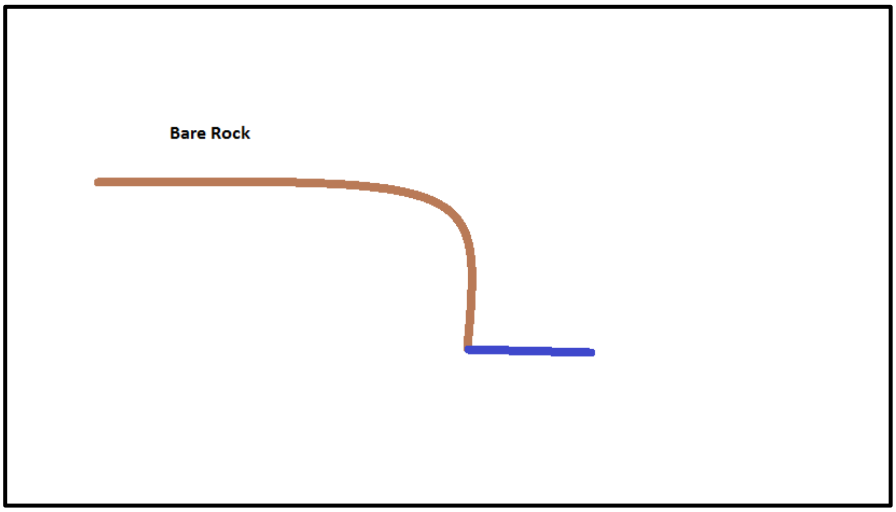

FIGURE 39: 004 VEGETATION COMMUNITY COMPOSITION

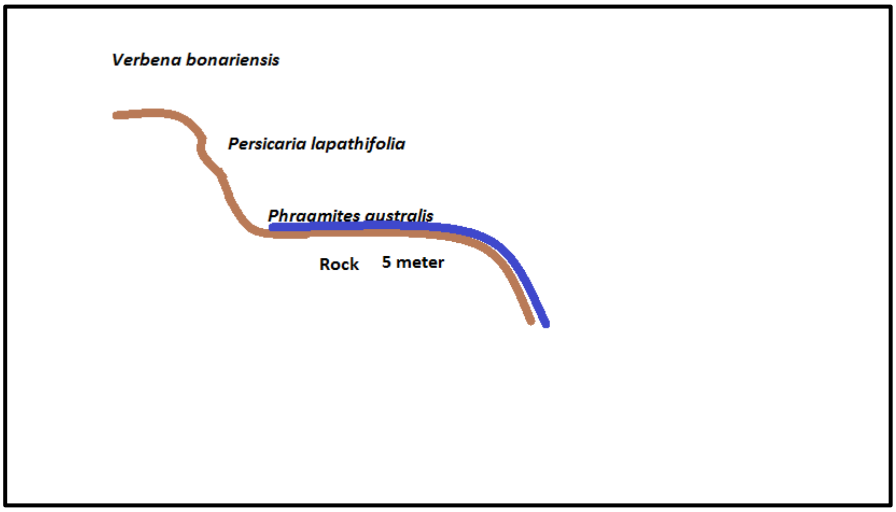

FIGURE 40: 005 VEGETATION COMMUNITY COMPOSITION

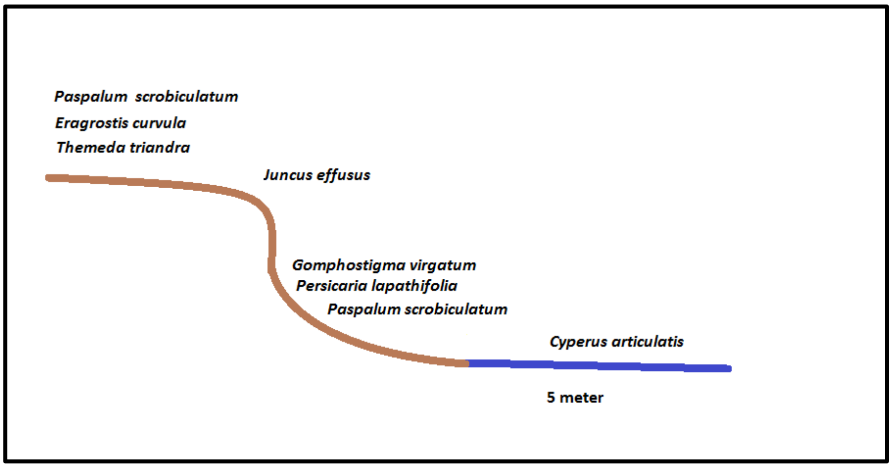

FIGURE 41: 006 VEGETATION COMMUNITY COMPOSITION

FIGURE 42: 007 VEGETATION COMMUNITY COMPOSITION

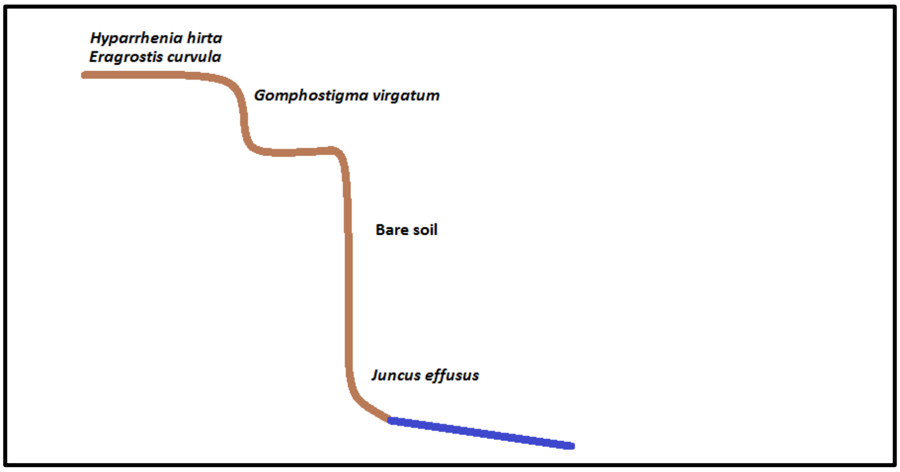

FIGURE 43: 008 VEGETATION COMMUNITY COMPOSITION

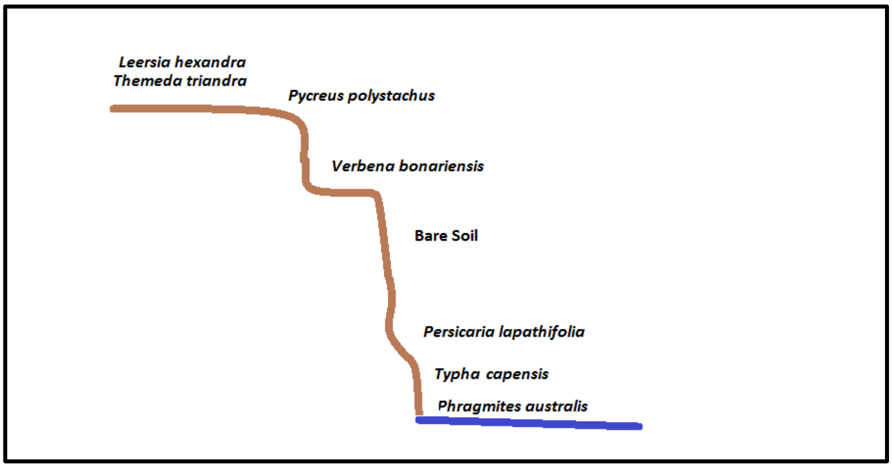

FIGURE 44: 009 VEGETATION COMMUNITY COMPOSITION

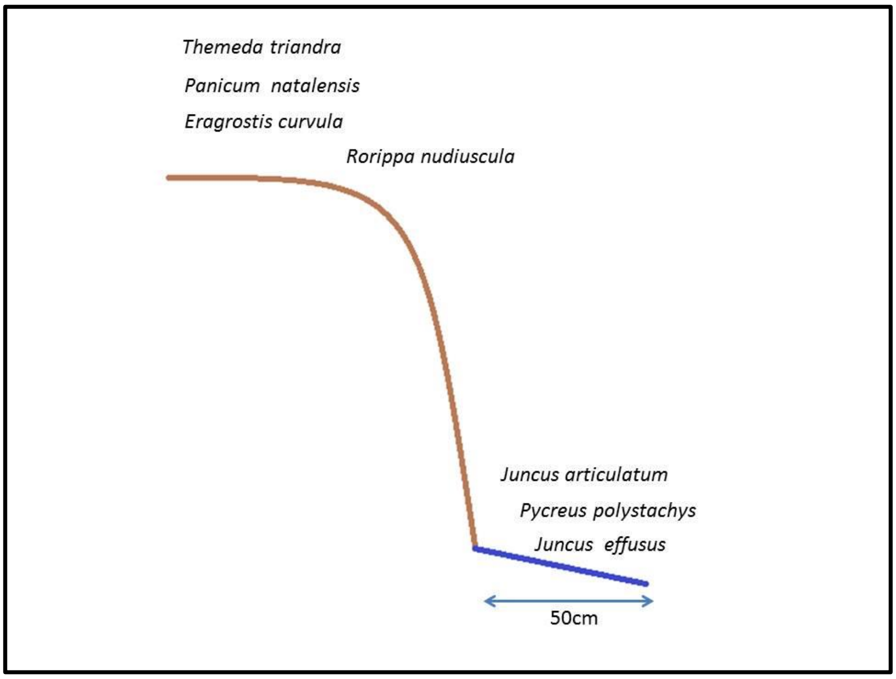

FIGURE 45: 010 VEGETATION COMMUNITY COMPOSITION

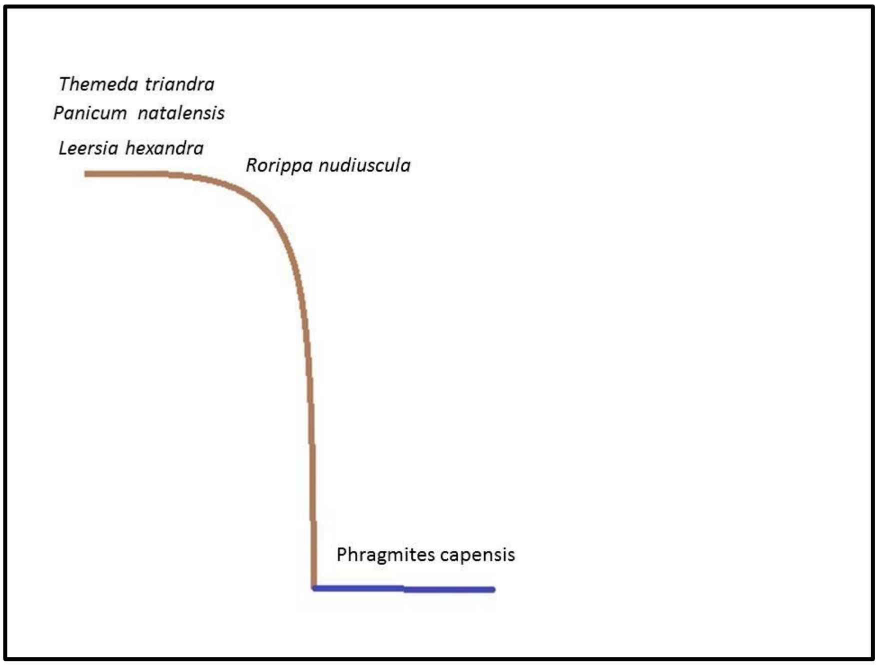

FIGURE 46: 011 VEGETATION COMMUNITY COMPOSITION

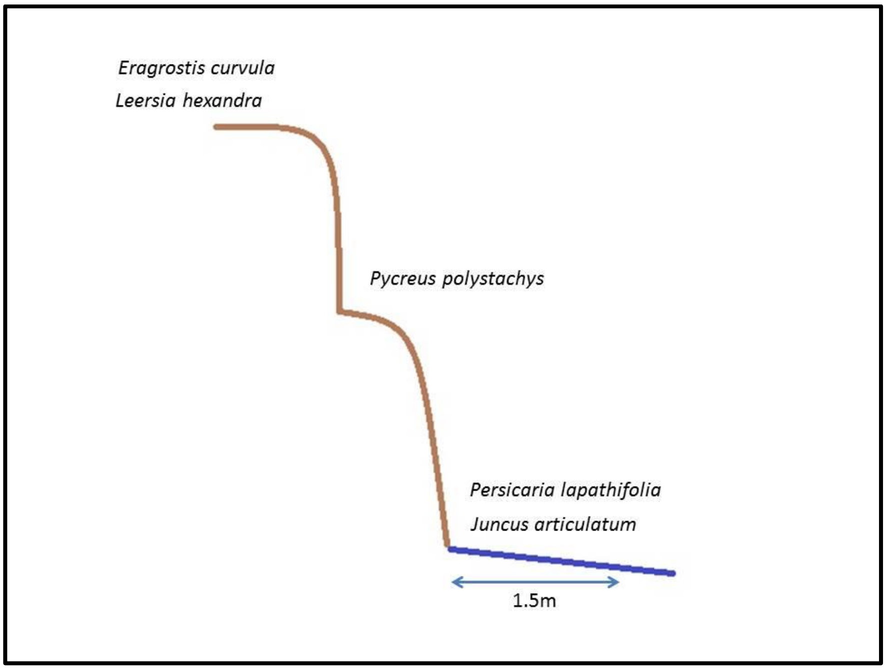

FIGURE 47: 012 VEGETATION COMMUNITY COMPOSITION

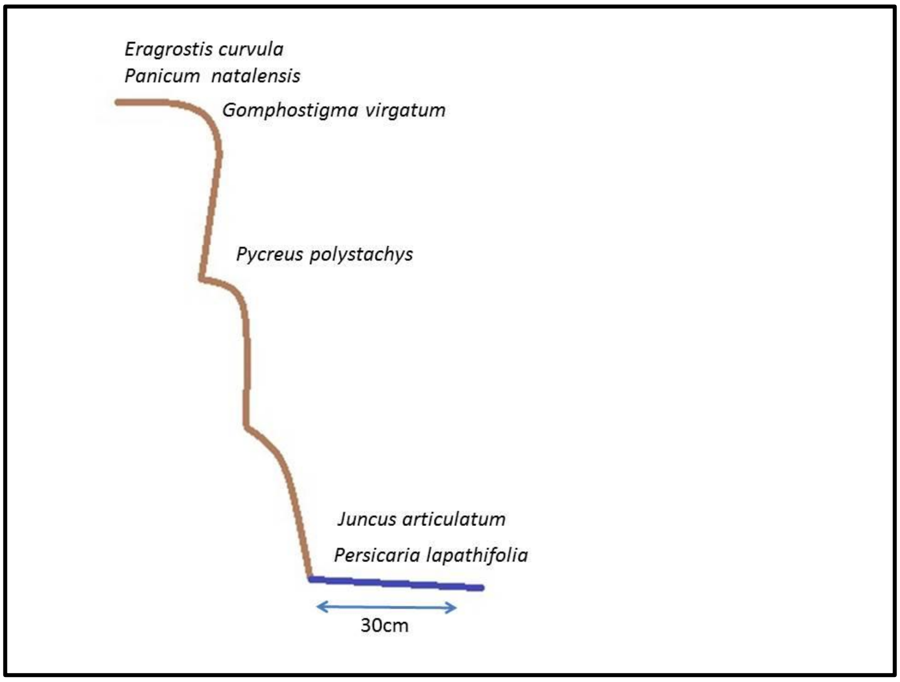

FIGURE 48: 013 VEGETATION COMMUNITY COMPOSITION

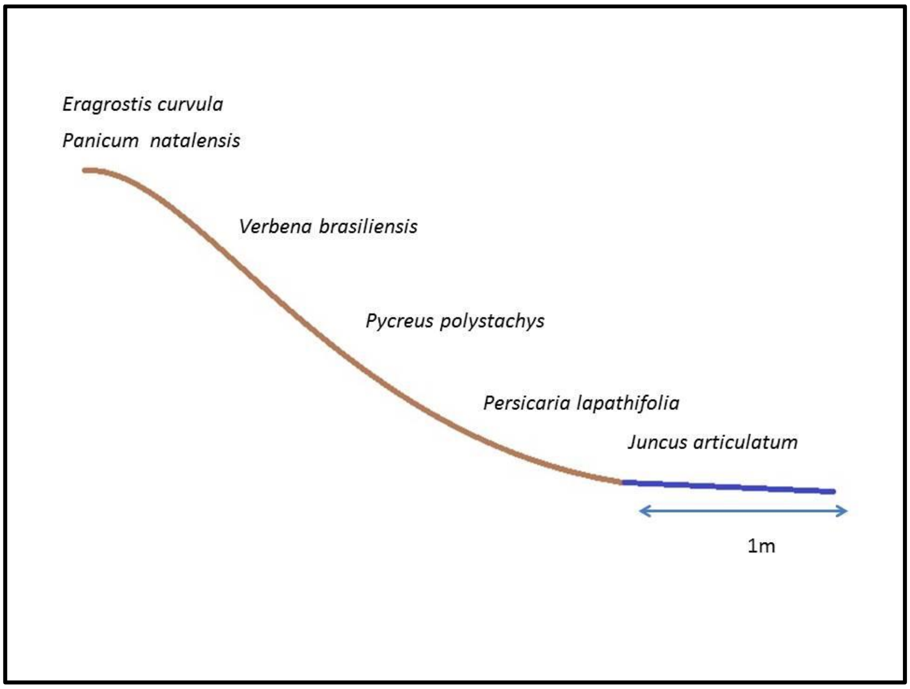

FIGURE 49: 014 VEGETATION COMMUNITY COMPOSITION

5.2.3.4. SASS species per plant presence

To assess the habitat provision of the plant species, the assessment of the presence of specific aquatic macroinvertebrates to plant species was completed. This includes population numbers to provide more accurate habitat use information. This information is used to infer the vegetation type with the best habitat for aquatic diversity. A combined pie graph of the vegetation type with the best habitat is given in Figure 50. This shows that Sedges has the largest species use (31%) and Phragmites second (21%). In Figure 51 it shows the number of total individuals per plant types. Sedges and Phragmites were very similar in this regard and made up almost 50% of the habitat provision.

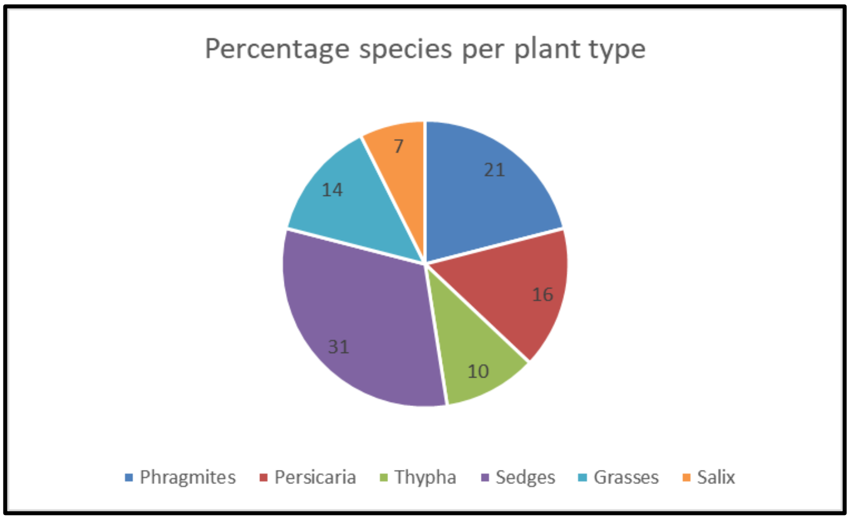

FIGURE 50: PIE GRAPH OF TOTAL TAXA PER PLANT TYPE

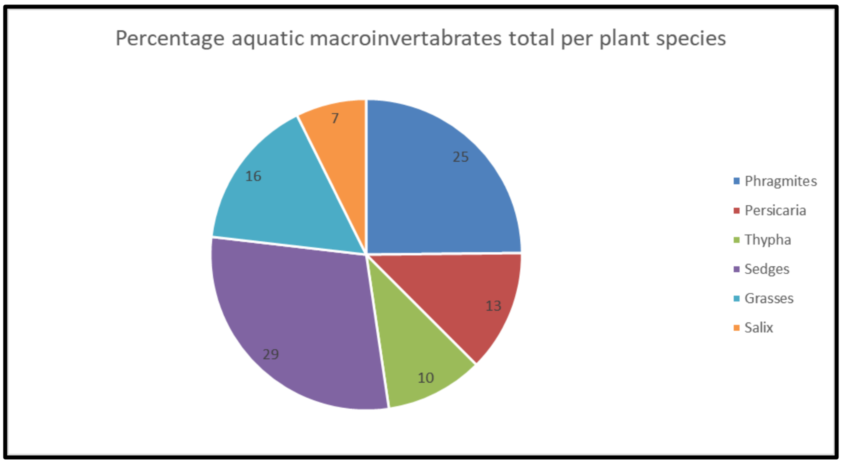

FIGURE 51: THE PERCENTAGE AQUATIC MACROINVERTEBRATE INDIVIDUALS PER PLANT TYPE.

5.2.3.5. Aquatic alien vegetation

Dense mats of the aquatic alien vegetation, parrots feather (*Myriophyllum aquaticum*), was observed in the wetland sample site (Figure 52). This is of concern as these plants can reproduce using vegetative methods and create an excellent seed bank in mud. Specific management is required in this regard to prevent the spread of the species.

FIGURE 52: PARROTS FEATHER (*MYRIOPHYLLUM AQUATICUM*) IN THE WETLAND SAMPLE SITE

6. Discussion, Impact assessment and general mitigation measures

The PES and EIS of the Olifants River systems found on site was calculated to PES= C and the EIS to High. Various mining activities in the catchment and close to the system occurs on site and throughout the river reach. The water quality assessment of the site did not show any real outliers- initially aspects such as pH, TDS/EC was expected to be higher due to the risk of salt mine drainage (SMD) and acid mine drainage (AMD) as collateral impact of coal mining on the river system. This was however not of confirmed with the EC/TDS results elevated but not within acute range (Table 20).

The aquatic species composition using the SASS5 methodology remains stable with the mean ASPT calculated to 5.0 for 2022 (Table 36). Due to the slow-deep nature of the river system on site the average SASS scores of the species observed was lower.

The proposed activities on site include the diversion of the Olifants River to allow for the mining of the remaining sections of underground pillars and posts. These sections extend under the Olifants River. The risk of SMD and AMD in these sections are very high and leaching of contaminated water from diffused sources into the river is of grave concern. Mining activities to the south of the proposed river diversion shows signs of this AMD leachate at the interface of the second seam of coal (Figure 53).

FIGURE 53: ORANGE SEEPAGE INDICATIVE OF AMD LEACHING INTO THE PIT

The proposed diversion of the river is approximately 400 meters long and will be cut into sandstone. The area of diversion is in a floodplain area at the leeway section of the river (Figure 54 and Figure 55). The concern with this is that the mining activities will remove a large section of the flood attenuation functionality of the river. Overtopping of the banks of the river into these sections is an infrequent activity and is suspected to occur only during high flow events (1:50/ 1:100-year floodings).

FIGURE 54: PROPOSED DIVERSION AREA FROM THE NORTHWEST FACING SOUTHEAST

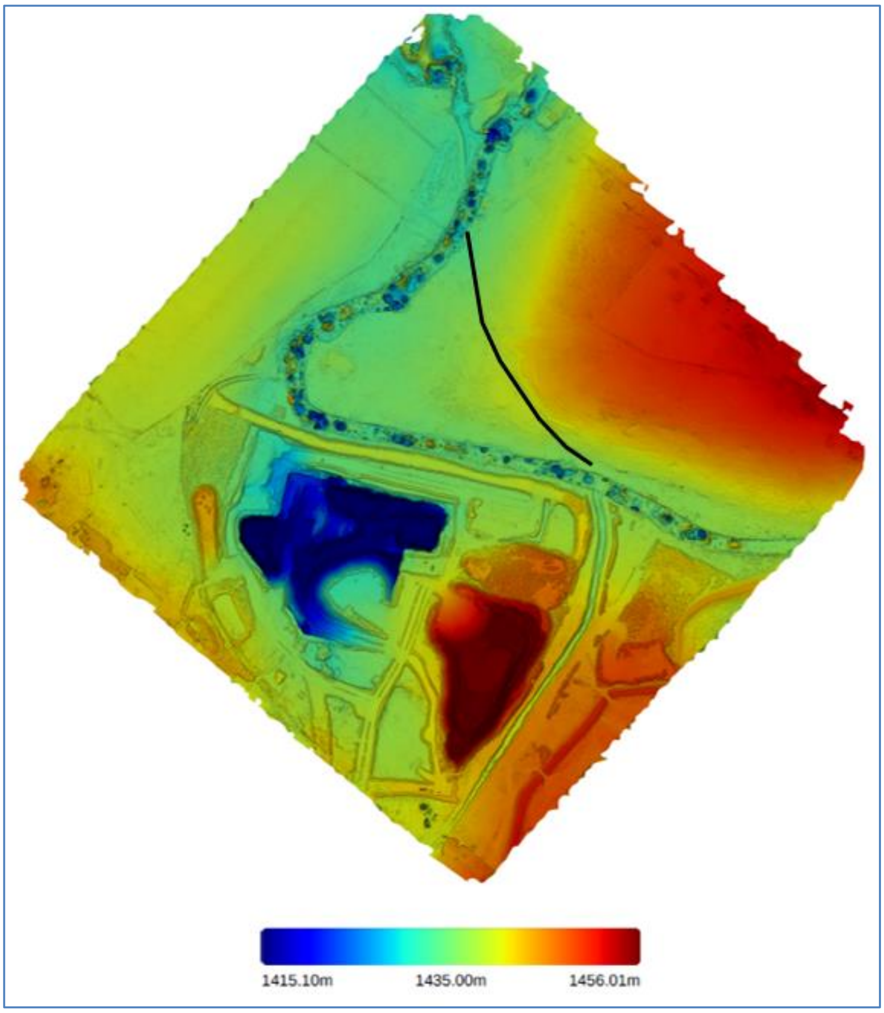

FIGURE 55: ELEVATION DATA FOR THE DIVERSION AREA (BLACK POLYGON)

The risk of AMD and SMD decanting from the existing underground mining operations is high. As it is suspected that the decant will be directly into the river the detection of the decant is near impossible. The river diversion for the mining operations will alter the decant point. The expected decanting points are given in Figure 56. See mitigation measures below ().

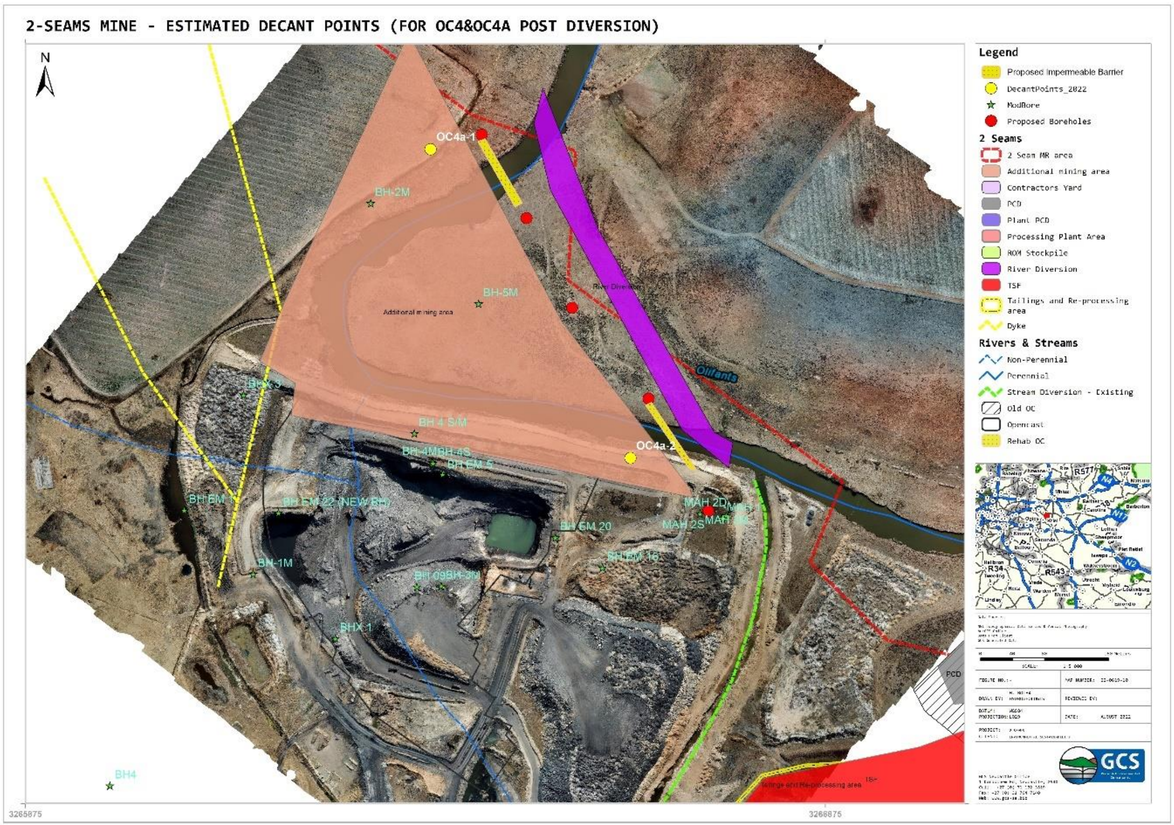

FIGURE 56: GEOHYDROLOGICAL DECANT POINTS

Additionally, the proposed activities on site include the following:

- New processing plant and run of mine stockpile,
- Tailings facility,
- Contractor yard,
- Two pollution control dams.

To assess the activities in terms of Gn509 (NWA, act 36 of 1998) and impact assessment general aspects of expected impacts was used to determine the risk and impact of these activities.

6.1. Impact assessment

6.1.1.River Diversion

In the case of the study site, the largest risk profile will be during the mining activities and is mitigated through the diversion of the river. Once completed and rehabilitation is in place the stability in the systems is expected. See the calculations of the impact in Table 38. The calculations determine the impact score before mitigation to ***High*** and ***Medium*** with mitigation measures.

TABLE 38: THE IMPACT SIGNIFICANCE BEFORE MITIGATION RATING SCALE- RIVER DIVERSION

	Prior to mitigation		Description of mitigation measure	After mitigation						
Aspect	Significance			Intensity and magnitude	Resource replaceability	Duration	Extent or spatial	Probability	Significance	
Flood attenuation	14	High	Diversion of the river with implementation of rehabilitation recommendations	2	2	1	1	1	7	LOW
Streamflow regulation	14	High		2	2	2	1	1	8	LOW
Sediment trapping	14	Medium		2	2	1	1	2	8	LOW
Phosphate assimilation	15	High		2	2	1	1	1	7	LOW
Nitrate assimilation	15	High		2	2	1	1	2	8	LOW
Toxicant assimilation	14	High		2	2	2	1	2	9	LOW
Erosion control	14	Low		1	2	1	1	2	7	LOW
Carbon storage	14	Medium		2	1	2	1	1	7	LOW
Habitat	14	Low		2	2	2	1	2	9	LOW
Hydrology	13	Medium		1	1	2	1	1	6	LOW
Eutrophication	14	High		1	1	1	1	2	6	LOW
Water quality	15	High		2	2	2	1	1	8	LOW
Geomorphology	15	High		1	1	1	1	2	6	LOW
Average	**14**	**HIGH**		**2**	**2**	**1**	**1**	**2**	**7**	**MEDIUM**

6.1.2.New processing plant

See the calculations of the impact in Table 39. The calculations determine the impact score before mitigation to Low and LOW with mitigation measures. This is due to the short duration of the activity proposed as well as the location of the plant in terms of aquatic ecosystems (Figure 57). The locality is also in an area already impacted by mining activities. It is of paramount importance that the storm water from these areas is all collated into a storm water management area leading to a pollution control dam (PCD).

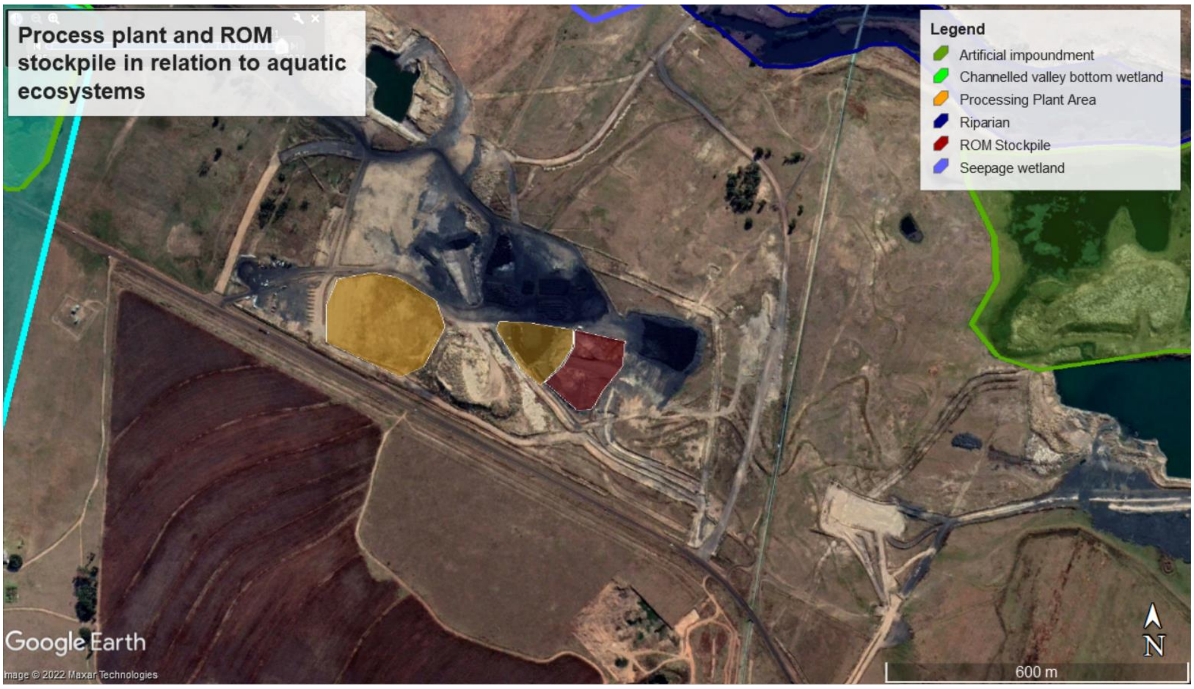

FIGURE 57: THE PROCESSING PLANT AND ROM STOCKPILE IN RELATION TO AQUATIC ECOSYSTEMS

TABLE 39: THE IMPACT SIGNIFICANCE BEFORE MITIGATION RATING SCALE- NEW PROCESSING PLANT AND ROM STOCKPILE

	Prior to mitigation		Description of mitigation measure	After mitigation						
Aspect	**Significance**			**Intensity and magnitude**	**Resource replaceability**	**Duration**	**Extent or spatial**	**Probability**	**Significance**	
Flood attenuation	6	Low	Attenuation of storm water into PCD	1	1	1	1	1	5	LOW
Streamflow regulation	7	Low		1	1	1	1	1	5	LOW
Sediment trapping	6	Low	Inclusion of sediment trap before the PCD	1	1	1	1	1	5	LOW
Phosphate assimilation	6	Low	Inclusion of phytoremediation aspects in the PCD and storm water aspects	1	1	1	1	1	5	LOW
Nitrate assimilation	7	Low		1	1	1	1	1	5	LOW
Toxicant assimilation	6	Low		1	1	1	1	1	5	LOW
Erosion control	5	Low	Attenuation of storm water. Prevent sheetflows from the activity	1	1	1	1	1	5	LOW
Carbon storage	5	Low	Inclusion of phytoremediation aspects in the PCD and storm water aspects	1	1	1	1	1	5	LOW
Habitat	5	Low		1	1	1	1	1	5	LOW
Hydrology	5	Low	Attenuation of storm water. Prevent sheetflows from the activity,	1	1	1	1	1	5	LOW
Water quality	7	Low	Ensure all storm water and sheet flows are directed to the PCD and the inclusion of phytoremediation measures in the storm water system	1	1	1	1	1	5	LOW
Geomorphology	5	Low	Not expected to be impacted due to the location and type of activity	1	1	1	1	1	5	LOW
Average	**6**	**LOW**		**1**	**1**	**1**	**1**	**1**	**5**	**LOW**

6.1.3.Tailings facility

See the calculations of the impact in Table 40. It is important to note that the Tailings Storage Facility is an existing structure with existing PCD system. This however did not decrease the impact assessment of the activity due to the scope of works. Any reworking in terms of removal of tailings for reworking will decrease the cumulative impact of the activity and decrease the duration of the activity.

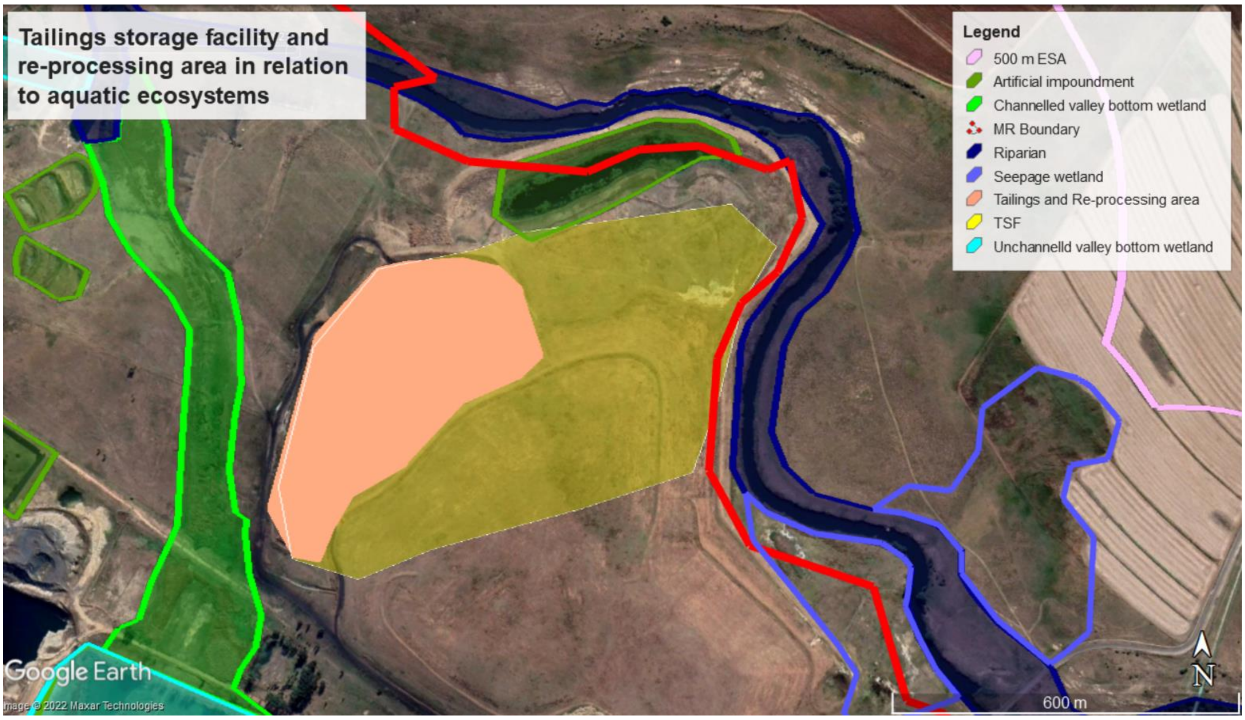

FIGURE 58: TAILINGS STORAGE AND REPROCESSING FACILITIES LOCALITY IN RELATION TO AQUATIC ECOSYSTEMS

TABLE 40: THE IMPACT SIGNIFICANCE BEFORE MITIGATION RATING SCALE- TSF AND RE-PROCESSING

	Prior to mitigation		Description of mitigation measure	After mitigation						
Aspect	Significance			Intensity and magnitude	Resource replaceability	Duration	Extent or spatial	Probability	Significance	
Flood attenuation	10	Medium	Attenuation of storm water into PCD	2	2	3	2	2	11	Medium
Streamflow regulation	11	Medium		2	2	2	2	2	10	Medium
Sediment trapping	12	High	Inclusion of sediment trap before the PCD	2	2	2	1	2	9	Medium
Phosphate assimilation	11	Medium	Inclusion of phytoremediation aspects in the PCD and storm water aspects	2	2	2	1	2	9	Medium
Nitrate assimilation	11	Medium		2	2	2	1	2	9	Medium
Toxicant assimilation	11	Medium		2	2	2	1	2	9	Medium
Erosion control	12	High	Attenuation of storm water. Prevent sheetflows from the activity	2	2	2	1	2	9	Medium
Carbon storage	14	High	Inclusion of phytoremediation aspects in the PCD and storm water aspects	2	2	2	2	2	10	Medium
Habitat	11	Medium		2	2	2	2	2	10	Medium
Hydrology	12	High	Attenuation of storm water. Prevent sheetflows from the activity,	2	2	2	2	2	10	Medium
Water quality	14	High	Ensure all storm water and sheet flows are directed to the PCD and the inclusion of phytoremediation measures in the storm water system	2	2	3	2	2	11	Medium
Geomorphology	12	High	Ensure slopes of structures is 1:3. Avoid concetrated flow releases	2	2	3	2	2	11	Medium
Average	**12**	**Medium**		**2**	**2**	**2**	**2**	**2**	**10**	**M EDIUM**

6.1.4.Contractor yard

The contractor's yard is near a channelled valley bottom wetland system (Figure 59). The yard must be cleared, and containment berm installed. The water from the site must be directed to a PCD/ storm water system. A sustainable urban drainage system must be installed to mitigate most of the expected impacts. See Table 41 for the impact assessment- the impact without mitigation was calculated to Low (7) and Low (6) after the implementation of mitigation measures.

TABLE 41: CONTRACTORS YARD IMPACT ASSESSMENT

	Prior to mitigation		Description of mitigation measure	After mitigation						
Aspect	Significance			Intensity and magnitude	Resource replaceability	Duration	Extent or spatial	Probability	Significance	
Flood attenuation	6	Low	Attenuation of storm water into PCD	1	1	1	1	2	6	Low
Streamflow regulation	7	Low		1	1	1	1	2	6	Low
Sediment trapping	7	Low	Inclusion of sediment trap before the PCD	1	1	1	1	2	6	Low
Phosphate assimilation	6	Low	Inclusion of phytoremediation aspects in the PCD and storm water aspects	1	1	1	1	2	6	Low
Nitrate assimilation	6	Low		1	1	1	1	2	6	Low
Toxicant assimilation	7	Low		1	1	1	1	2	6	Low
Erosion control	7	Low	Attenuation of storm water, with reduction in sheetflow	1	1	1	1	2	6	Low
Carbon storage	7	Low	Inclusion of phytoremediation aspects in the PCD and storm water aspects	1	1	1	2	2	7	Low
Habitat	7	Low		1	1	1	2	2	7	Low
Hydrology	8	Medium	Attenuation of storm water. Prevent sheetflows from the activity,	1	1	1	2	2	7	Low
Water quality	8	Medium	Ensure all storm water and sheet flows are directed to the PCD/ storm water attenuation structure and the inclusion of phytoremediation measures in the storm water system	1	1	1	2	2	7	Low
Geomorphology	8	Medium	Ensure slopes of structures is 1:3. Avoid concetrated flow releases	1	1	1	2	2	7	Low
Average	**7**	**Low**		**1**	**1**	**1**	**1**	**2**	**6**	**Low**

FIGURE 59: CONTRACTORS YARD IN RELATION TO AQUATIC ECOSYSTEMS

6.1.5. Pollution control dams (PCD)

PCD systems are of paramount importance for the management of polluted waters and preventing "dirty" water from mixing with "clean" water. The northern PCD is already in place and is associated with the TSF and tailings reprocessing works. See Table 42 for the impact assessment. Due to the nature of the system the PCD itself is the primary mitigative measure for the impact.

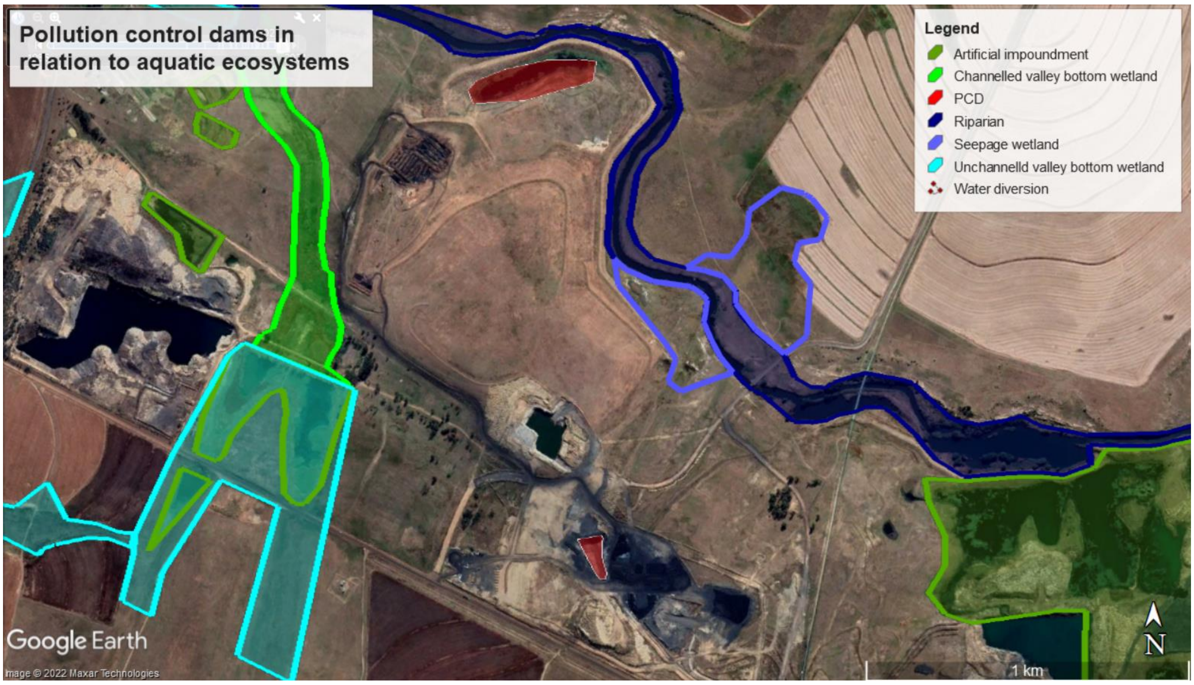

FIGURE 60: POLLUTION CONTROL DAMS IN RELATION TO THE AQUATIC ECOSYSTEMS

TABLE 42: PCD IMPACT ASSESSMENT

Aspect	Prior to mitigation		Description of mitigation measure	After mitigation						
	Significance			Intensity and magnitude	Resource replaceability	Duration	Extent or spatial	Probability	Significance	
Flood attenuation	6	Low		1	1	1	1	2	6	Low
Streamflow regulation	6	Low		1	1	1	1	2	6	Low
Sediment trapping	6	Low		1	1	1	1	2	6	Low
Phosphate assimilation	6	Low		1	1	1	1	2	6	Low
Nitrate assimilation	6	Low		1	1	1	1	2	6	Low
Toxicant assimilation	6	Low		1	1	1	1	2	6	Low
Erosion control	6	Low	Due to the nature of the PCD the system itself will be the mitigation	1	1	1	1	2	6	Low
Carbon storage	6	Low		1	1	1	1	2	6	Low
Habitat	6	Low		1	1	1	1	2	6	Low
Hydrology	6	Low		1	1	1	1	2	6	Low
Water quality	6	Low		1	1	1	1	2	6	Low
Geomorphology	6	Low		1	1	1	1	2	6	Low
Average	**6**	**Low**		**1**	**1**	**1**	**1**	**2**	**6**	**Low**

6.1. GN509 Risk assessment

See Table 43 for a list of the risk assessment aspects as well as calculation scores. For the sake of comparability, the risk assessment aspects were kept the same. The diversion was assessed separately.

Table 43: GN509 risk assessments

Aspect	Table reference	Risk calculation result
River diversion	Table 44	96.7 = ***Moderate Risk***
New processing plant	Table 45	41= ***Low Risk***
Tailings facility re-processing	Table 46	100= ***Moderate Risk***
Contractor yard	Table 47	87= ***Moderate Risk***
Pollution control dams	Table 48	93= ***Moderate Risk***

TABLE 44: GN 509 RISK ASSESSMENT RIVER DIVERSION

Phases	Activity	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorphic and Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance		Risk Rating: 1 – 55 (Low Risk) 56-169 (Moderate Risk) 170-300 (High risk)	Confidence level (as %)	Control Measures	Borderline LOW MODERATE Rating Classes	PES AND EIS OF WATERCOURSE
	SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS) (How will the proposed activities on site impact on the EIS of the aquatic ecosystem)	Removal of stockpile revegetation of impacted areas after removal	5	5	5	5	5	3	5	13	5	5	5	5	20	260	260	High Risk	95	Monitoring of site with feedback to ensure the application of mitigation measures		
Concept of proposed activities	**STATUS (PRESENT ECOLOGICAL STATUS - PES) (How will the proposed activities on site impact on the PES of the aquatic ecosystem)**	Improve of water quality by removal of materials from stockpile	5	5	5	5	5	3	5	13	5	5	5	5	20	260	260	High Risk	95	Monitoring of systems to detect degradation of the systems		**Please see aqautic ecosystem delineation report as completed for the project**
	RISKS TO RESOURCE QUALITY (Cumulative risk to resource quality)	The average of this risk assessment (see final row)	4	3	3	3	3	3	4	10	4	4	5	3	16	164	164	High Risk	100	See mitigation measures below		
	Stripping of topsoil	Sediment ingress into the aquatic ecosystem, clearing of vegetation	2	1	2	2	2	1	2	5	1	2	5	2	10	48	48	Low risk	95	Initiate removal at highest level working downward. Only remove sections of topsoil in relation to removal work.		
Pre-mining/ diversion	**River diversion**	Diverison of the Olifants River	5	5	5	5	5	3	5	13	5	5	5	5	20	260	260	High Risk		See rehabilitation plan		
	Stockpiling of topsoil	Sediment releases, impact of area disturbed by stockpile	2	1	2	1	2	1	1	4	1	1	5	3	10	35	35	Low risk	95	Berming of stockpile, slope 1:3, revegetation of stockpile		

Phases	Activity	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorphic and Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance		Risk Rating: 1 – 55 (Low Risk) 56-169 (Moderate Risk) 170-300 (High risk)	Confidence level (as %)	Control Measures	Borderline LOW MODERATE Rating Classes	PES AND EIS OF WATERCOURSE
Operational mining	Excavation	Area impacted by placement of soils on surface next to excavation	5	3	2	2	3	2	2	7	5	5	2	3	15	105	105	Moderate Risk	100	Small volumes to be stockpiled. Ensure stockpile is within stormwater management areas	Remains after review	Please see aqautic ecosystem delineation report as completed for the project
		Sediment ingress	5	1	1	1	2	1	3	6	5	5	2	3	15	90	90	Moderate Risk	95	Monitor points of release, ensure bunding of stockpiles		
		Increased flow volumes	5	2	1	2	3	1	2	6	5	5	5	3	18	99	99	Moderate Risk	95	Monitor points of release, ensure bunding of stockpiles. Installation of windrows to ensure water movement does not concentrate and lead to erosion		
		Impact on long term ecosystem health	5	1	2	1	2	1	3	6	5	5	5	3	18	113	113	Moderate Risk	90	Monitor the systems with emphasis on water quality and preventative measures to ensure degradation is observed and mitigated		
		Reduced functionality of buffer	5	1	1	1	2	3	2	7	5	5	5	3	18	126	126	Moderate Risk	95	Management of water flows downstream of activity with monitoring and feedback. Emergency reaction plan to be compiled to manage stochastic events		
		Ecotone removal	5	2	1	1	2	1	3	6	5	5	5	3	18	113	113	Moderate Risk	95	Ensure activities adjacent to the aquatic ecosystems are managed/ limited to ensure impact is mitigated		
		Possible spillage into natural area	5	1	1	1	2	1	3	6	5	4	5	3	17	102	102	Moderate Risk	95	Bunding of stockpiles, placement of berms along natural areas to prevent ingress. Defined works areas demarcated		
		Refilling of machinery with hydrocarbons	5	4	2	3	4	1	1	6	5	5	5	3	18	99	99	Moderate Risk	95	Done outside the confines of the aquatic ecosystems and setback buffers. Spill kits present. Refilling over bunded area		
		Stockpiling of soils	5	2	1	2	3	1	2	6	5	4	5	3	17	94	94	Moderate Risk	95	Bunding of stockpiles, placement of berms along natural areas to prevent ingress		
		Physical excavation in soil	5	2	2	2	3	1	2	6	5	5	5	3	18	104	104	Moderate Risk	95	Sequential nature of soils are kept. Stockpiling done outside setback areas, bunding of stockpiles	Remains after review	
	Transportation from site	Area impacted by waiting trucks and machinery	2	2	1	2	2	1	2	5	5	5	5	3	18	86	86	Moderate Risk	95	Minimise areas of impact. Created sloped and controlled waiting area. Ensure adequate toilet facilities are available		
		Crossing of aquatic ecosystem on existing roads and bridges	5	2	2	1	3	1	2	6	5	5	5	3	18	99	99	Moderate Risk	95	Manage hydrology avoiding impounding by crossing structure. Sloping of banks to 1:3. reseed after construction.		
	Hydrocarbon spill	Possible spillage into natural area	5	3	1	2	3	1	2	6	5	3	5	3	16	92	92	Moderate Risk	95	Do not refill near aquatic ecosystems and or setbacks. Placement of spill kits near all activities and in each vehicle		
		Refilling of machinery	5	3	1	3	3	1	2	6	5	5	5	3	18	108	108	Moderate Risk	95	Refilling over hydrocarbon spill remediation blankets. No refilling near aquatic ecosystems. Ensure spill kits are on standby close to refilling point		
	Access road	Crossing of aquatic ecosystem with machinery	5	2	1	2	3	2	2	7	5	5	5	3	18	117	117	Moderate Risk	95	Long term crossing structure must be constructed to prevent repeated impacts. Ensure hydrological connections remain. Reduce sediment ingress into the aquatic ecosystems using sediment barriers.	Remains after review	
	Impoundment of water in excavation pit	During rainfall events the excavation pit can fill with water (unlikely but included)	5	3	3	2	3	1	1	5	5	5	5	3	18	95	95	Moderate Risk	95	Pumping and clearing into sediment control structures. Diffused flows must be achieved using sediment barriers. Compilation of Standard Operating Procedure to manage impact		
	Alien vegetation spreading and establishment	Alien vegetation establishment and spread	5	5	5	5	5	3	2	10	5	5	5	3	18	180	180	High Risk	95	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.		

Phases	Activity	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorphic and Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance		Risk Rating: 1 – 55 (Low Risk) 56-169 (Moderate Risk) 170-300 (High risk)	Confidence level (as %)	Control Measures	Borderline LOW MODERATE Rating Classes	PES AND EIS OF WATERCOURSE
Post development/ rehabilitation	Decompaction of soil	Ripping of access roads to reduce compaction	1	2	2	2	2	1	2	5	1	3	5	1	10	48	48	Low risk	95	Ripping must follow contours of landscape creating windrows.		Please see aqautic ecosystem delineation report as completed for the project
	Removal of crossings over aquatic ecosystem	Altering of beds and banks	2	3	3	2	3	2	1	6	1	1	5	1	8	44	44	Low risk		Sediment reducing barriers must be installed downstream of the crossing. Working from upstream structures must be removed as quickly as possible		
		Sediment ingress	1	3	2	2	2	2	1	5	1	1	5	1	8	40	40	Low risk		installation of sediment reducing structures- sand bags		
	Infilling of soil and or placement of topsoil	Replacement of soil into excavated area (unlikely)	2	3	2	2	2	1	2	5	1	1	5	2	9	47	47	Low risk	95	Infilling of lowest point or closest to the aquatic ecosystem must be completed first. Temporary berm must be placed adjacent to the aquatic ecosystem until all filling has been completed. Work must follow contours of area creating windrows		
		Moving of topsoil from stockpile rehabilitated areas	2	2	2	1	2	1	2	5	2	2	5	2	11	52	52	Low risk	95		Remains after review	
		Levelling of topsoil's	2	2	2	2	2	1	2	5	1	1	5	2	9	45	45	Low risk	95			
	Erosion of replaced soils	Replaced surface soils are washed away if not stabilised or planted before the first rainfall	1	2	2	2	2	1	2	5	2	2	5	2	11	52	52	Low risk	90	Refilling of eroded areas with coarser topsoil to prevent erosion. Management of reseeding in area to prevent erosion.		
	Alteration of soil chemical properties	Alteration of soil chemical properties- reducing soil productivity	1	2	1	1	1	1	2	4	2	2	5	3	12	51	51	Low risk	95	Application of fertilisers to manage altered soil chemical properties.		
	Alien vegetating eradication	Application of herbicides	1	3	2	2	2	1	2	5	2	2	5	1	10	50	50	Low risk	95	Management of alien vegetation throughout the activities on site		
MEAN			3,7	2,5	2,1	2,2	2,6	1,5	2,3	6,4	3,7	3,7	4,8	2,8	15,0	96,7	97	Moderate Risk	95			

TABLE 45: GN509 RISK ASSESSMENT FOR THE NEW PLANT

Phases	Activity	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorphic and Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating: 1 – 55 (Low Risk) 56-169 (Moderate Risk) 170-300 (High risk)	Control Measures	Borderline LOW MODERATE Rating Classes	PES AND EIS OF WATERCOURSE
Concept of proposed activities	RISKS TO RESOURCE QUALITY	Cumulative risk to resource quality- see final row	1	1	2	2	1	1	1	4	4	4	1	3	12	42	Low risk	See mitigation measures below		Please see aqautic ecosystem delineation report as completed for the project
	SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS)	How will the proposed activities on site impact on the EIS of the aquatic ecosystem	1	1	1	1	1	1	1	3	5	4	1	4	14	42	Low risk	Monitoring of site with feedback to ensure the application of mitigation measures		
	STATUS (PRESENT ECOLOGICAL STATUS - PES)	How will the proposed activities on site impact on the PES of the aquatic ecosystem	1	1	1	1	1	1	1	3	5	4	1	4	14	42	Low risk	Monitoring of systems to detect degradation of the systems		
Operational	New processing plant	Flood attenuation	1	1	1	2	1	1	1	3	5	5	1	3	14	46	Low risk	Use of PCD and storm water systems to manage attenaution of storm water		Please see aqautic ecosystem delineation report as completed for the project
		Streamflow regulation	1	1	1	2	1	1	1	3	5	5	1	3	14	46	Low risk	Use of PCD and storm water systems to manage attenaution of storm water		
		Sediment trapping	1	1	1	1	1	1	1	3	5	5	1	3	14	42	Low risk	Installation of sediment traps before storm water systems		
		Phosphate assimilation	1	1	1	1	1	1	1	3	5	5	1	3	14	42	Low risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems		
		Nitrate assimilation	1	1	1	1	1	1	1	3	5	4	1	3	13	39	Low risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems		
		Toxicant assimilation	1	1	1	3	2	1	1	4	5	5	1	3	14	49	Low risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems		
		Erosion control	1	1	1	1	1	1	1	3	5	4	1	3	13	39	Low risk	Management of storm water to prevent concentrated flows		
		Carbon storage	1	1	1	1	1	1	1	3	5	5	1	3	14	42	Low risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems		
		Alien vegetation establishment and spread	1	1	3	5	3	3	1	7	5	5	1	3	14	91	Moderate Risk	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.		
Post development and rehabilitation	Decompaction, infilling of soil and or placement of topsoil	Ripping of area and access roads to reduce compaction	1	2	2	2	2	1	1	4	1	3	1	1	6	23	Low risk	Ripping must follow contours of landscape creating windrows.		Please see aqautic ecosystem delineation report as completed for the project
		Replacement of soil	1	2	2	2	2	1	1	4	1	1	1	2	5	19	Low risk	Infilling of lowest point or closest to the aquatic ecosystem must be completed first. Temporary berm must be placed adjacent to the aquatic ecosystem until all filling has been completed. Work must follow contours of area creating windrows		
		Moving of topsoil from stockpile rehabilitated areas	1	2	2	1	2	1	1	4	2	2	1	2	7	25	Low risk			
		Levelling of topsoils	1	2	2	2	2	1	1	4	1	1	1	2	5	19	Low risk			
	Alien vegetating eradication	Application of herbicides	1	3	3	3	3	1	2	6	2	2	1	1	6	33	Low risk	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.		
MEAN			**1**	**1**	**2**	**2**	**1**	**1**	**1**	**4**	**4**	**4**	**1**	**3**	**11**	**41**	Low risk			

TABLE 46: GN509 RISK ASSESSMENT FOR THE TAILINGS AND TAILINGS RE-PROCESSING

Phases	Activity	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorphic and Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating: 1 – 55 (Low Risk) 56-169 (Moderate Risk) 170-300 (High risk)	Control Measures
Concept of proposed activities	RISKS TO RESOURCE QUALITY	Cumulative risk to resource quality- see final row	2	2	2	2	2	1	4	7	4	4	5	3	15	102	Moderate Risk	See mitigation measures below
	SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS)	How will the proposed activities on site impact on the EIS of the aquatic ecosystem	2	1	2	2	2	2	3	7	5	4	5	4	18	122	Moderate Risk	Monitoring of site with feedback to ensure the application of mitigation measures
	STATUS (PRESENT ECOLOGICAL STATUS - PES)	How will the proposed activities on site impact on the PES of the aquatic ecosystem	2	1	1	2	2	1	3	6	5	4	5	4	18	99	Moderate Risk	Monitoring of systems to detect degradation of the systems
Operational	Tailings and tailings re-processing	Flood attenuation	2	1	1	2	2	1	3	6	5	5	5	3	18	99	Moderate Risk	Use of PCD and storm water systems to manage attenaution of storm water
		Streamflow regulation	2	1	1	2	2	1	3	6	5	5	5	3	18	99	Moderate Risk	
		Sediment trapping	2	1	1	1	1	1	3	5	5	5	5	3	18	95	Moderate Risk	Installation of sediment traps before storm water systems
		Phosphate assimilation	2	3	2	1	2	1	3	6	5	5	5	3	18	108	Moderate Risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems
		Nitrate assimilation	2	3	1	1	2	1	3	6	5	4	5	3	17	98	Moderate Risk	
		Toxicant assimilation	1	3	2	3	2	1	3	6	5	5	5	3	18	113	Moderate Risk	
		Erosion control	2	3	2	1	2	1	3	6	5	4	5	3	17	102	Moderate Risk	Management of storm water to prevent concentrated flows
		Carbon storage	1	3	1	1	2	1	3	6	5	5	5	3	18	99	Moderate Risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems
		Alien vegetation establishment and spread	2	1	3	5	3	3	3	9	5	5	5	3	18	158	Moderate Risk	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.
Post development and rehabilitation	Decompaction, infilling of soil and or placement of topsoil	Ripping of area and access roads to reduce compaction	1	1	2	2	2	1	5	8	1	2	5	1	9	68	Moderate Risk	Ripping must follow contours of landscape creating windrows.
		Replacement of soil	1	1	2	2	2	1	5	8	1	1	5	2	9	68	Moderate Risk	Infilling of lowest point or closest to the aquatic ecosystem must be completed first. Temporary berm must be placed adjacent to the aquatic ecosystem until all filling has been completed. Work must follow contours of area creating windrows
		Moving of topsoil from stockpile rehabilitated areas	1	2	2	1	2	1	5	8	2	2	5	2	11	83	Moderate Risk	
		Levelling of topsoils	1	1	2	2	2	1	5	8	1	1	5	2	9	68	Moderate Risk	
	Alien vegetating eradication	Application of herbicides	1	3	3	3	3	1	5	9	1	2	5	1	9	77	Moderate Risk	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.
MEAN			**2**	**2**	**2**	**2**	**2**	**1**	**4**	**7**	**4**	**4**	**5**	**3**	**15**	**100**	**Moderate Risk**	

TABLE 47: GN509 RISK ASSESSMENT FOR THE NEW CONTRACTORS YARD

Phases	Activity	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorphic and Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating: 1 – 55 (Low Risk) 56-169 (Moderate Risk) 170-300 (High risk)	Control Measures
Concept of proposed activities	RISKS TO RESOURCE QUALITY	Cumulative risk to resource quality- see final row	2	2	2	2	2	1	4	7	4	2	5	3	13	87	Moderate Risk	See mitigation measures below
	SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS)	How will the proposed activities on site impact on the EIS of the aquatic ecosystem	2	1	2	2	2	2	3	7	5	4	5	4	18	122	Moderate Risk	Monitoring of site with feedback to ensure the application of mitigation measures
	STATUS (PRESENT ECOLOGICAL STATUS - PES)	How will the proposed activities on site impact on the PES of the aquatic ecosystem	2	1	1	2	2	1	3	6	5	4	5	4	18	99	Moderate Risk	Monitoring of systems to detect degradation of the systems
Operational	Contractors yard	Flood attenuation	4	1	1	1	2	1	3	6	5	2	5	1	13	75	Moderate Risk	Use of PCD and storm water systems to manage attenuation of storm water
		Streamflow regulation	4	1	1	1	2	1	3	6	5	2	5	1	13	75	Moderate Risk	
		Sediment trapping	2	1	1	1	1	1	3	5	5	1	5	2	13	68	Moderate Risk	Installation of sediment traps before storm water systems
		Phosphate assimilation	2	3	2	1	2	1	3	6	5	1	5	5	16	96	Moderate Risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems
		Nitrate assimilation	2	3	1	1	2	1	3	6	5	1	5	5	16	92	Moderate Risk	
		Toxicant assimilation	2	2	2	2	2	1	3	6	5	1	5	5	16	96	Moderate Risk	
		Erosion control	2	2	2	1	2	1	3	6	5	1	5	1	12	69	Moderate Risk	Management of storm water to prevent concentrated flows
		Carbon storage	2	3	1	1	2	1	3	6	5	1	5	1	12	69	Moderate Risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems
		Alien vegetation establishment and spread	3	2	3	5	3	3	3	9	5	3	5	3	16	148	Moderate Risk	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.
Post development and rehabilitation	Decompaction, infilling of soil and or placement of topsoil	Ripping of area and access roads to reduce compaction	1	1	2	2	2	1	5	8	1	2	5	1	9	68	Moderate Risk	Ripping must follow contours of landscape creating windrows.
		Replacement of soil	1	1	2	2	2	1	5	8	1	1	5	2	9	68	Moderate Risk	Infilling of lowest point or closest to the aquatic ecosystem must be completed first. Temporary berm must be placed adjacent to the aquatic ecosystem until all filling has been completed. Work must follow contours of area creating windrows
		Moving of topsoil from stockpile rehabilitated areas	1	2	2	1	2	1	5	8	2	2	5	2	11	83	Moderate Risk	
		Levelling of topsoils	1	1	2	2	2	1	5	8	1	1	5	2	9	68	Moderate Risk	
	Alien vegetating eradication	Application of herbicides	1	3	3	3	3	1	5	9	1	2	5	1	9	77	Moderate Risk	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.
MEAN			2	2	2	2	2	1	4	7	4	2	5	3	13	87	Moderate Risk	

Table 48: GN509 risk assessment for the two pollution control dams

Phases	Activity	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorphic and Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating: 1 – 55 (Low Risk) 56-169 (Moderate Risk) 170-300 (High risk)	Control Measures
Concept of proposed activities	RISKS TO RESOURCE QUALITY	Cumulative risk to resource quality- see final row	2	2	2	2	2	1	3	7	5	2	5	3	14	93	Moderate Risk	See mitigation measures below
	SENSITIVITY (ECOLOGICAL IMPORTANCE AND SENSITIVITY – EIS)	How will the proposed activities on site impact on the EIS of the aquatic ecosystem	2	1	2	2	2	2	3	7	5	4	5	4	18	122	Moderate Risk	Monitoring of site with feedback to ensure the application of mitigation measures
	STATUS (PRESENT ECOLOGICAL STATUS - PES)	How will the proposed activities on site impact on the PES of the aquatic ecosystem	2	1	1	2	2	1	3	6	5	4	5	4	18	99	Moderate Risk	Monitoring of systems to detect degradation of the systems
Operational	Contractors yard	Flood attenuation	4	3	2	2	3	1	3	7	5	2	5	1	13	88	Moderate Risk	Use of PCD and storm water systems to manage attenaution of storm water
		Streamflow regulation	4	1	1	2	2	1	3	6	5	2	5	1	13	78	Moderate Risk	
		Sediment trapping	2	1	1	2	2	1	3	6	5	1	5	2	13	72	Moderate Risk	Installation of sediment traps before storm water systems
		Phosphate assimilation	2	3	2	2	2	1	3	6	5	1	5	5	16	100	Moderate Risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems
		Nitrate assimilation	2	3	2	1	2	1	3	6	5	1	5	5	16	96	Moderate Risk	
		Toxicant assimilation	2	2	2	2	2	1	3	6	5	1	5	5	16	96	Moderate Risk	
		Erosion control	2	2	2	1	2	1	3	6	5	1	5	1	12	69	Moderate Risk	Management of storm water to prevent concentrated flows
		Carbon storage	2	3	1	1	2	1	3	6	5	1	5	1	12	69	Moderate Risk	Inclusion of phytoremediation aspects in all PCD and Storm water systems
		Alien vegetation establishment and spread	3	2	3	5	3	3	3	9	5	3	5	3	16	148	Moderate Risk	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.
Post development and rehabilitation	Alien vegetating eradication	Application of herbicides	1	3	3	3	3	1	5	9	1	2	5	1	9	77	Moderate Risk	Management of alien vegetation throughout the activities on site. Must be completed through alien vegetation management plan. Removal throughout activities on site and not as once off.
MEAN			2	2	2	2	2	1	3	7	5	2	5	3	14	93	Moderate Risk	

6.2. Mitigation of proposed impact

The mitigation of the impacts to the system is based on the perceived impacts for the proposed activities. The most effective mitigation is the awareness of possible issues before they occur. This is difficult to achieve especially during long term projects with existing latent impacts. To ensure the issues are mitigated it is recommended that an Aquatic environmental control officer (AECO) is appointed for the duration of the project. The AECO will be tasked with assessing field conditions and ensure impacts to the aquatic ecosystem is managed.

The primary mitigation of the mining is the diversion of the river system. The diversion will cause the loss of ecological divers that was formed over millennia. Most concerning is the loss of attenuation functionality of the system. To mitigate this loss of the floodplain area it is proposed that the existing Mistake Lake to the north of the diversion is used for this functionality (Figure 61). It must be noted that Mistake Lake was an old mining area, and the risk of SMD and AMD remains. Additional fortification in conjunction with additional monitoring is proposed to assess the impact of the use of this section. The inlet to the lake is degraded and additional clearing of the area and removal of old structures are required (Figure 62).

FIGURE 61: LAYOUT OF THE MISTAKE LAKE

FIGURE 62: INLET TO THE MISTAKE LAKE

Additional specific mitigation measures include:

- Compilation of systematic adaptive rehabilitation plan (see section 7 below),
- Compilation of monitoring plan to ensure impacts are timeously observed and addressed as soon as possible,
- Implementation of an early warning system to prevent incidences of flooding inundating machinery and decrease risk to human health,
- Management on site must take cognizance of possible pollution arising from the site, with emphasis on AMD, hydrocarbon, and sediment pollution,
- Signage must also be included to increase awareness of the aquatic ecosystems found on site,

6.3. General mitigation measures

The following general mitigation measures are proposed[6]:

- An alien vegetation eradication programmed should be implemented on the site to remove the alien vegetation from the wetland areas.
- An environmental control officer (ECO), specialising in aquatic systems (AECO) must be appointed throughout the project to ensure the longevity of the impacted aquatic system.
- The use of cement lined channels must be avoided at all costs and lining must be done with Loffel stones (or Amourflex stones) or similar products. This is to prevent the loss of habitat to aquatic organisms living in the system.
- The ramps for the in- and out flows from the construction site must be lined with Reno mattresses and or gabions to prevent structure undermining and to ensure flow is dispersed and mitigated. Vertical steps should not exceed 200 mm, to ensure aquatic fauna movement and migration.
- The use of gabion structures, well keyed into the surrounding bank walls and secured to the ground is recommended where required.
- If any construction activity must occur within the riparian areas, then it must commence from upstream proceeding downstream with proper sedimentation barriers in place to prevent sediments and pollution moving downstream from the site. This includes non-perennial systems.
- The removal and translocation of impacted hydrophytes must be done prior to construction commencing.
- Due to the perennial nature of the system, construction should preferably commence during the dry months.
- All sensitive areas together with the associated buffer zones should be fenced during the construction phase to prevent any human activity from encroaching onto these areas. Monitoring of the fences is of paramount importance to ensure no infringement of the fences occurs.

[6] The contractor appointed for construction must be contractually bound to the requirements and mitigating measures listed in this document and any other documents relating to the construction (ecological management plan, rehabilitation plant etc.).

A full list is included here albeit *not all is* applicable to the site.

- Removal of debris and other obstructing materials from the site must take place and erosion-preventing structures must be constructed. This is done to prevent damming of water and increasing flooding danger.
- Removed soil and stockpiling of soil must occur outside the extent of the watercourse to prevent siltation and increased runoff during construction. This includes the buffer zones and 1:100-year flood lines.
- Proper toilet facilities must be located outside the sensitive areas: The impact of human waste on the system is immense. Chemical toilets must be provided which should always be well serviced and spaced as per occupational health and safety laws and placed outside the buffer and 1:100-year flood lines.
- Spill kits must be stored on site: In case of accidental spills of oil, petroleum products etc., good oil absorbent materials must be on hand to allow for the quick remediation of the spill. The kits should also be well marked, and all personnel should be educated to deal with the spill. Vehicles must be kept in good working order and leaks must be fixed immediately on an oil absorbent mat. The use of a product such as Sunsorb is advised.
- No plant machinery may be stored or left near the aquatic areas, when not in use.
- Frequent inspection of the site must be done to ensure that no harmful practices occur on site.
- A photo collection must be taken from fixed demarcated spots to detect changes in the construction area over time. These photographs must be dated and should include the entire site.
- No construction personnel can collect, harvest, or kill any species of fauna and flora on the site.
- Any species of fauna encountered during the construction phase should be moved to a safe location where no harm can be bestowed on the species.
- If water is sprayed on the construction surface for any reason during the construction process, utmost care must be taken to ensure the runoff water does not pollute the system or any of the associated catchment areas. A storm water cut-off drain should be constructed between the construction area and the aquatic system to ensure that storm water flowing through the construction area cannot flow into the aquatic system. The water from the cut-off drain must be collected in a sedimentation pond before entering the aquatic system.
- Any new erosion gullies must be remediated immediately.
- Construction should commence during the dry season or when flows are at their lowest where reasonably possible.

- Regular inspection of erosion preventing devices is needed.
- Construction camps: Plant parking areas and material stockpiles must be located outside the extent of the wetland.
- Access routes should be demarcated and located properly so that no damage to the system can occur. These roads must always be adhered to. A large turning place must be provided for larger trucks and machinery. No grading of temporary access roads is allowed as this will create dust and water runoff problems.
- Increased runoff due to removal of vegetation and increased soil compaction must be managed to ensure the prevention of siltation and the maximum stream bank stability.
- The velocity of storm water must be attenuated and spread. As far as possible the link between the stream and the local environment must be maintained. This is to ensure water movement into the soils and ensuring the survival of associated vegetation.
- Storm water leaving the site downstream must be clean and of the same quality as in situ before it enters the construction site (upstream). Preconstruction measures must be in place to ensure sediments are trapped.
- The overall alluvial characteristics of the drainage line (balance between sand, gravel, and stone) must be like before construction to ensure natural systems of flooding and sedimentation deportation and conveyance occur.

7. Rehabilitation plan

Rehabilitation plans for aquatic ecosystems are only as efficient as the implementers of the plan, the experience of the aquatic ecosystem specialist guiding the process and the willingness of the construction crews and developer to adhere to the rehabilitation plan. For this reason, it is of paramount importance that all parties involved be contractually bound to all aspects of this rehabilitation plan. This plan is written to be more of a practical report for the implementation of the rehabilitation measures than a purely theoretical report. For this reason, the implementation of the rehabilitation measures must be guided by an aquatic environmental control officer (AECO) with experience in implementing aquatic ecosystem rehabilitation. Also, this document is not set in prescriptive terms but rather offered as an adaptive management approach.

7.1. Mitigation and mitigation hierarchy

The Mitigation Hierarchy presented in the National Framework for Biodiversity Offsets, adapted to wetlands is as follows (WRC Report no TT 658/16). Four main mitigations are proposed: Avoid or Prevent, Minimise, Rehabilitate and Offset (Figure 63).

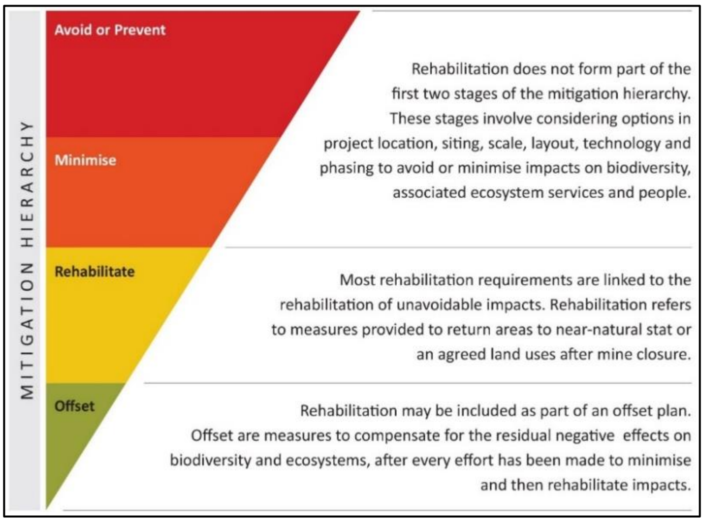

FIGURE 63: MITIGATION HIERARCHY

These aspects are based on the premise of avoidance, minimisation and compensation backed by monitoring (Figure 64) to reduce the impact of the activities. Development has several impacts on the surrounding environment and particularly on an aquatic ecosystem. Particularly services installation affects surface and subsurface water flows in a catchment and consequently affects recharge and discharge of water and the hydrological expression in aquatic ecosystems. If the mitigation and impact reduction relationships are correctly applied the biodiversity impacts can be mitigated as per Figure 65.

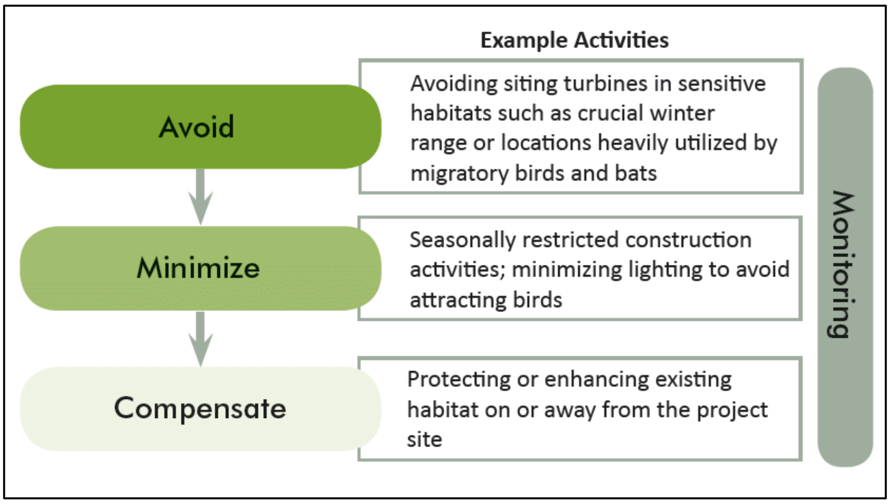

FIGURE 64: RELATIONSHIP OF IMPACT REDUCTION

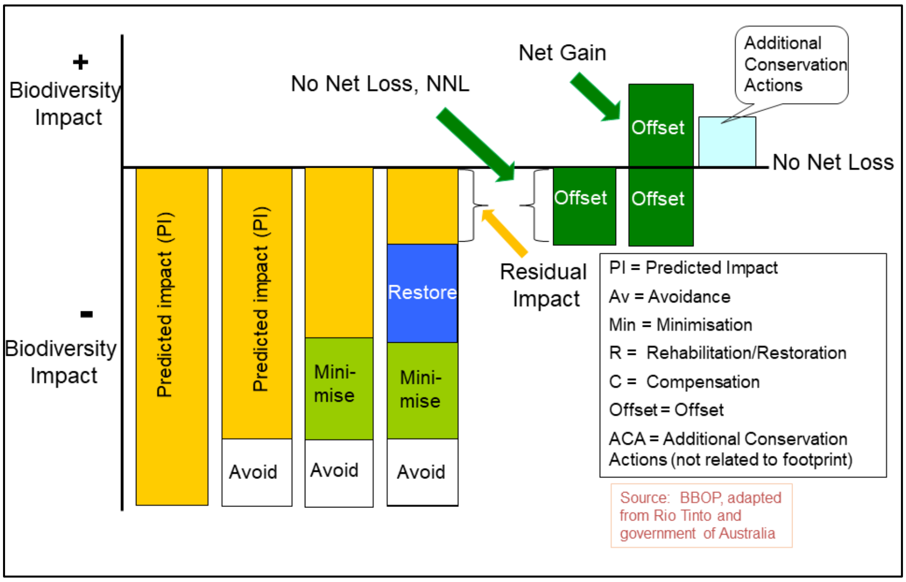

FIGURE 65: RELATIONSHIPS OF POSITIVE AND NEGATIVE BIODIVERSITY IMPACTS

See Table 49 for the summary of the various actions of mitigation hierarchy of the project.

TABLE 49: SUMMARY OF THE MITIGATION HIERARCHY OF THE PROJECT

Hierarchy	River diversion	New processing plant	Tailings facility	Contractor yard	Pollution control dams
Avoid or prevent	**NO GO:** Project does not continue. Site remains *in situ*. Risk of AMD to Olifants River possibly increases	**NO GO:** The processing plant is not built. It is unclear if the whole project is feasible without this plant	**NO GO:** The existing tailings are left in situ. This will lead to increased AMD risks.	**NO GO:** The contractors will use random areas for maintenance etc.	**NO GO:** PCD systems are critical and must be included.
	Avoid: Difficult- the river is over the source of AMD	**Avoid:** in terms of aquatic ecosystems the placement of the plant is avoiding impacts	**Avoid:** Re-process the TSF and decrease the AMD risk.	**Avoid:** See mitigation measures as included in the impact assessment with emphasis on storm water management	**Avoid:** N/A
Minimise	All aquatic ecosystem areas are avoided by services installation activities -this will be difficult on site. Removal and storage of any possible hydrophytes in the area (limited volumes expected), Stripping of topsoil, Stockpiling of the stripped topsoil, Monitoring plan	Ensure all storm water of the area drains to the PCD/ storm water system. These systems must incorporate Sustainable urban drainage system principals with increased phytoremediation. Separation of “clean” and “dirty” water sources. Dust management must take cognisance of dust accumulation into aquatic ecosystems.	Ensure all storm water of the area drains to the PCD/ storm water system. These systems must incorporate Sustainable urban drainage system principals with increased phytoremediation. Work must commence in the direction of the PCD.	Ensure all storm water of the area drains to the PCD/ storm water system. These systems must incorporate Sustainable urban drainage system principals with increased phytoremediation. The yard must be Bermed to prevent ingress of pollutants into the wetland. Bunding of fuel stores and sewage systems. Placement of hazardous materials and waste as far away as possible from the wetland systems.	Ensure all storm water of the area drains to the PCD/ storm water system. These systems must incorporate Sustainable urban drainage system principals with increased phytoremediation. Development and inclusion of overtopping warning system with emergency response plan.

Hierarchy	River diversion	New processing plant	Tailings facility	Contractor yard	Pollution control dams
Rehabilitate	Divert the flow of the Olifants River	Proposed placement is adequate offset for impact mitigation.	Revegetate workings areas after reclamation Offset impact by decreasing working footprint	Rehabilitate impacted area	The PCD will remain in situ after activities. Increase phytoremediation efforts in the PCD, Lining of PCD
Offset	Rehabilitate diversion, Offset of floodplain area into the Mistake Lake	Rehabilitation after use	Removal of old tailings and reworking will be the offset	Rehabilitation after use	No offset viable as these systems are crucial to the impact mitigations of the operation
Additional recommendations	Quarterly assessment of alien vegetation establishment is required to ensure this impact does not occur on the stockpiles and the services installation areas. Removal must be completed as per the approved alien vegetation eradication plan.	Monitoring in terms of water pollution and dust generation. Bunding of area with direction of storm water to PCD/ storm water management areas	Monitor of ground and surface water	Compilation of Standard operating procedure for management of risk in terms of aquatic ecosystems	Compilation of Standard operating procedure for management of risk in terms of aquatic ecosystems

7.1.1.Rehabilitation and reinstatement

Closure objectives, closure success criteria and relinquishment criteria are defined as:

- "**Objectives** define strategies or implementation steps to attain the identified **goals**. Unlike **goals**, **objectives** are specific, measurable, and have a defined completion date".
- **Closure success criteria** is when the objectives for closure are met with set measurable outcomes for success
- "**Relinquishment** is achieved through demonstration of achievement on closure completion criteria agreed with the primary regulator".

See **Figure** 66 below for a graphical presentation of the relationships.

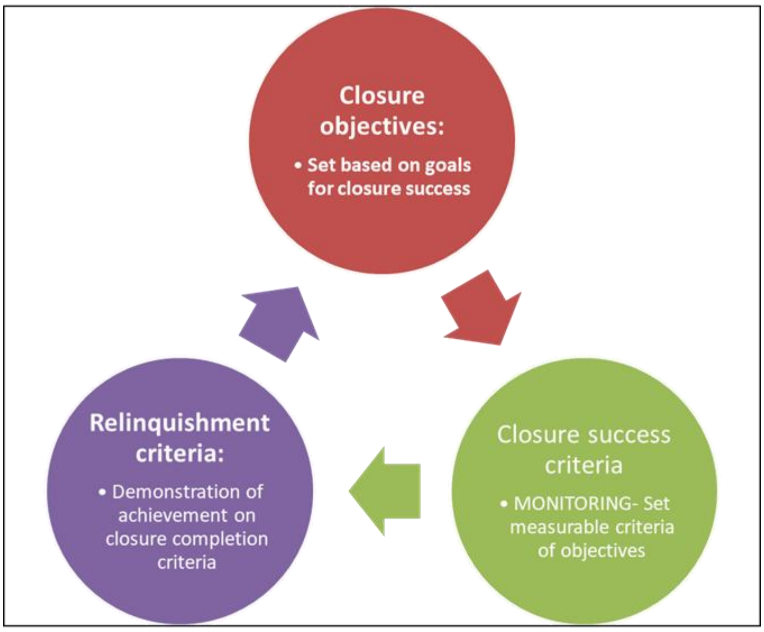

FIGURE 66: RELATIONSHIP BETWEEN CLOSURE OBJECTIVES AND CLOSURE SUCCESS CRITERIA AND RELINQUISHMENT CRITERIA

7.2. Objectives of the rehabilitation

To allow for the mining of the section the diversion of the river is required. The diversion is thus the primary mitigation aspect, and the rehabilitation effort needs to focus on this. The diversion of the river will be a permanent impact. Post mining the river will not be rerouted to its previous route due to the risk of acid mine drainage in the old mining areas. This influences the goals of the rehabilitation. The new diversion channel must for all aspects be similar in habitat provision to the aquatic fauna occurring naturally in the system. Thus, the goals of the diversion rehabilitation are simply:

“To emulate pre-diversion riparian conditions (abiotic and biotic) in the diversion”

“To reduce impact of developments post mining”

This includes form and function of the current system in the new system. The following important aspects must be kept in mind during the planning of the diversion:

- Current river channel not homogenous, varies in composition,
- Rehab aspects in place before diversion can commence,
- Water filling of new channel is of concern due to increased sediments in the channel,
- Rock boulders found in places- need to be kept if possible- this helps create habitat,
- Sectional approach to the diversion of water,
- Pumping of water from diverted area,
- Aquatic fauna relocated from old channel,
- Functional length lost in the system,
- Floodplain area impact due to loss.

7.3. Phasing of project

To ensure the impacts of the diversion is minimised, it is proposed that the diversion of the river and wetland must be done is phases. This must be read with 7.4 below.

7.3.1. Phase 1

- All crew and personnel associated with the project receive training regarding work in and around the aquatic ecosystems.
- All sensitive areas are demarcated until impacts are to occur in the systems,
- Planning and permitting requirements completed,
- Pre-impact monitoring and sampling completed.

7.3.2. Phase 2

Establishment of soil stockpile for excavated soils from the new channel. A small berm is always required around the stockpile to prevent any stochastic event from washing the stockpile into the riparian area. Once the diversion is complete, the soils can be removed and reused.

FIGURE 67: PHASE 2- STOCKPILE ESTABLISHMENT

7.3.3.Phase 3

Phase 3 (Figure 68) involves the excavation of the centre section of the diversion channel. No water inlets are to be completed. No machinery may cross the aquatic ecosystem at this stage. The excavations must be done and completed as much as possible. As this is an important part of the diversion, final levels must be made before the next phase.

FIGURE 68: PHASE 3- EXCAVATIONS OF DRY AREA CENTRAL AREA

From the in-situ studies the bank morphology requirements of the diversion can be emulated. This includes the shape and levels as well as hydrological functions. As the riparian system is currently in average 2 meters deep, excavations must be done to this depth. Spots of deeper pools must be made, with depths of up to 3 to 4 meters (Figure 26) with a diameter of 20 meters.

The hydrological functions for the same section of diversion can be compared to the in-situ conditions. It is important that the banks are as flat as possible for the section where the river enters the diversion, to allow for overtopping during flooding. The area must have the same shape as the sample points. See Figure 69 for the bank shapes and Table 33 for raw data.

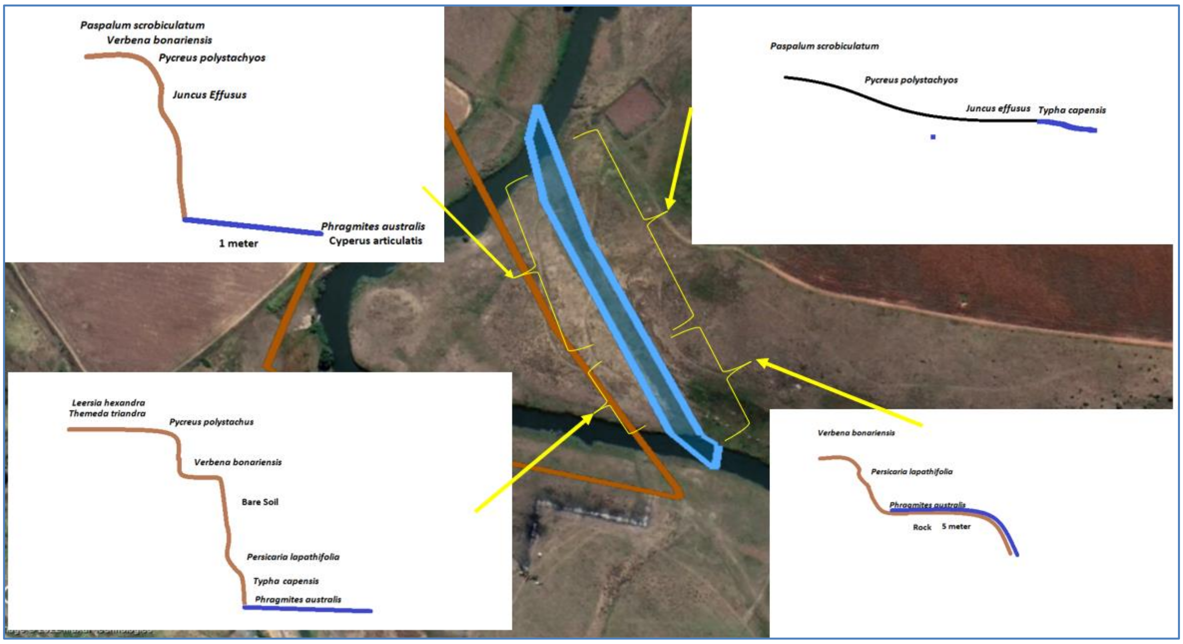

FIGURE 69: BANK SHAPE REQUIRED BY THE NEW CHANNEL TO EMULATE HABITAT

7.3.4. Phase 4

Phase 4 is a high-risk portion of the development, as this is the inlet of water into the new diversion. Water must be allowed to enter the diversion excavation, only once the AECO signs off on Phase 3. The excavations are high risk as the required depth of the channel might be difficult to achieve. The machinery will have to extent the booms and buckets into the water of the system. It is important that the release of water into the diversion be done in segments, and not one massive flow of water with high velocity (and thus increased erosion and sediment loads in the system). Site specific planning must be confirmed by the AECO for the project before any works commence.

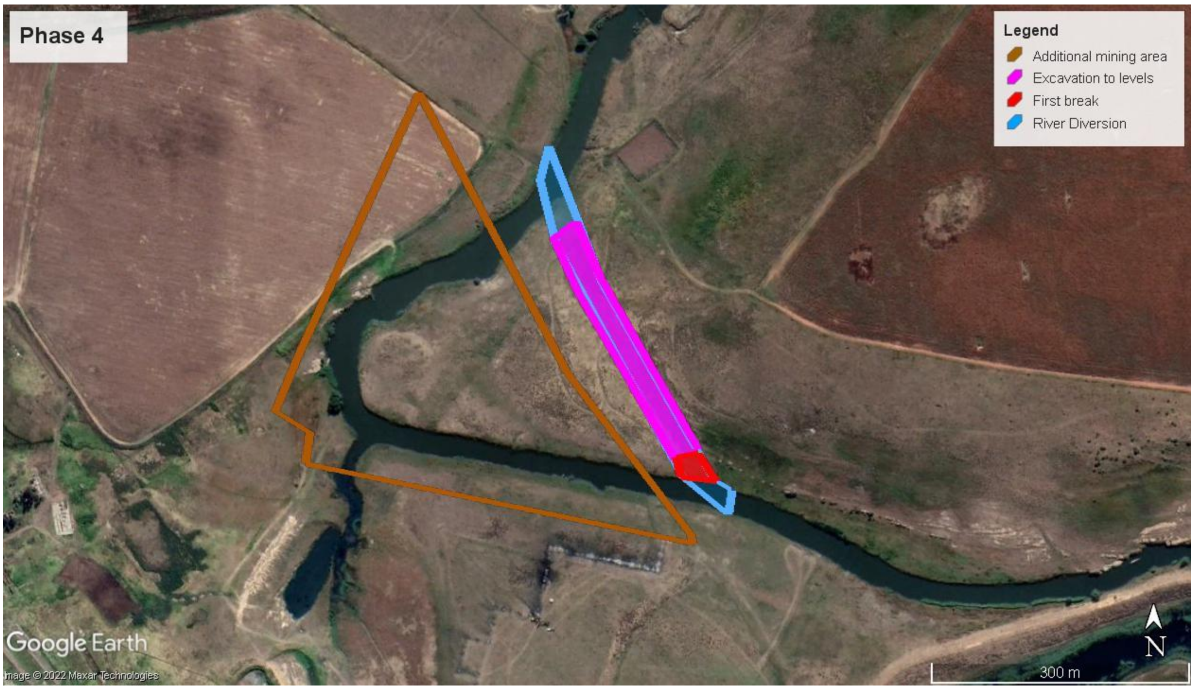

FIGURE 70: PHASE 4 LOCATION AND PLAN

It is during this phase that all marginal flora species must be replanted in accordance with the in-situ surveys of the system. These species must be removed from the current active channel and replanted here. This includes al hydrophytes. Removal must be done with as much of the root system as possible (Figure 71).

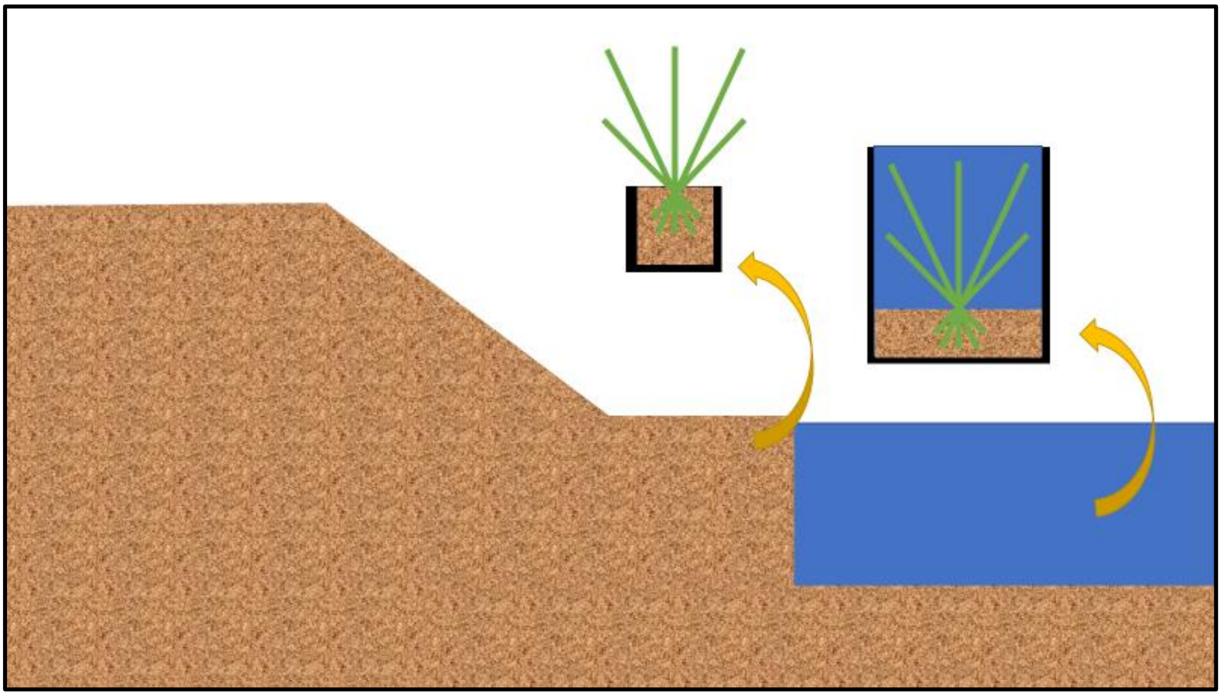

FIGURE 71: PLANT REMOVAL AND RELOCATION

Important species that requires removal is given in Table 50 below. Most of the plants listed are not commercially available and *in site* sourcing is of paramount importance. Other grass species seed is available and must be sourced as soon as possible for the project. A total of 15 kg seed per ha is required. Species included in the list is: *Cynodon dactylon, Eragrostis curvula, Hyparrhenia hirta*[7], *Leersia hexandra, Panicum natalensis, Paspalum scrobiculatum* and *Themeda triandra*[8]. Reference literature is available from (van Ginkel *et al.*, 2011), and the AECO must assist with this process.

TABLE 50: LIST OF PLANTS TO BE REMOVED IN PHASES 1 TO 3

	Gomphostigma virgatum, Leersia hexandra, Paspalum scrobiculatum, Pycerus poystachyos, Rorippa nudiuscula, Verbena bonariensis.
	*Juncus articulatus*
	*Persicaria lapathifolia*
	*Juncus effusus*
	*Typha capensis*
	*Phragmites australis and Phragmites capensis*

[7] Seedlings must be propagated of the seed to ensure growth

[8] Seedlings must be propagated of the seed to ensure growth

7.3.5.Phase 5

It is important that the planting of the marginal plants must be completed before phase 5 can start. Once this is in place the final break of the diversion can be completed (Figure 72). This will alter the water quality composition of the system, as high volumes of sediments and increased turbidity is expected. It is important that the break must be completed in segments, and the water is allowed to enter the natural channel with low velocities.

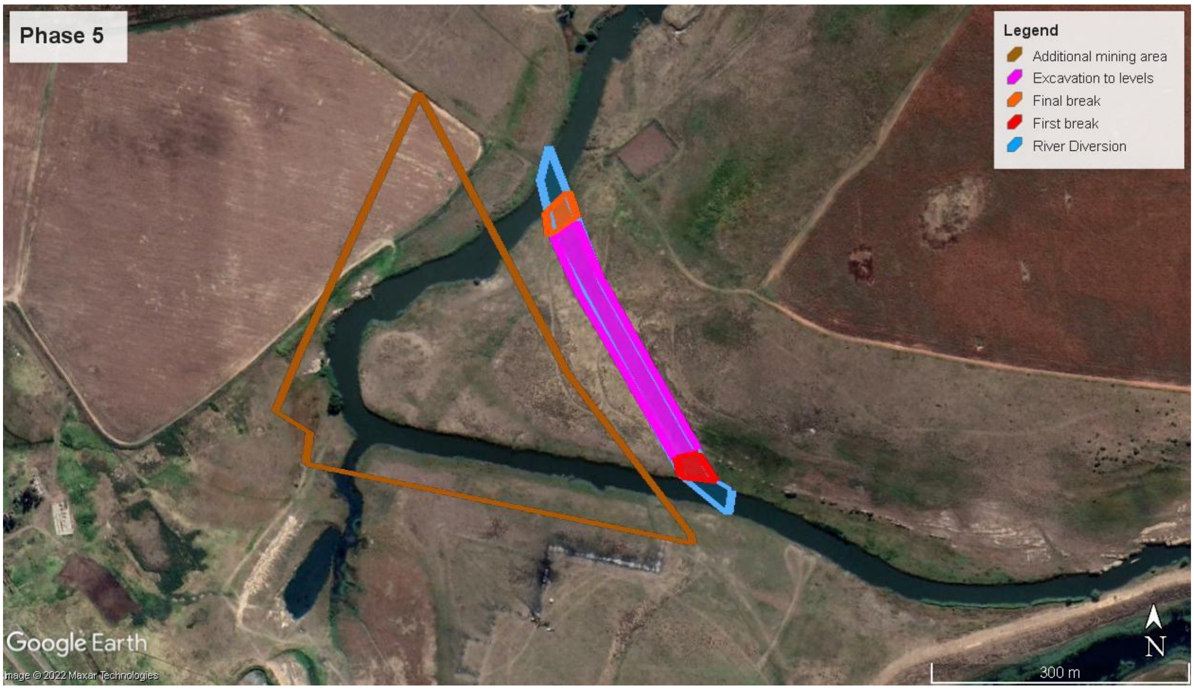

FIGURE 72: PHASE 5 OF THE DIVERSION

7.3.6.Phases 6 and 7

The next two phases will involve the placement of a berm in the existing natural channel and the reduction in flows in the old channel. The flows are very low in the system naturally, and in combination with the large volume of water in the channel, will be the most timeously process of the diversion. The closure of the system must be done using river sand, or similar material, to reduce the number of sediments and turbidity produced by the activity. The water needs to have a low flow rate- this will be difficult to achieve. Thus, the reasons for the river sand. The use of large boulders can also be used to raise the initial channel depth.

Once the downstream plug is in place (Figure 73), and the AECO signs off on the process, the upstream plug can be made in similar fashion (Figure 74).

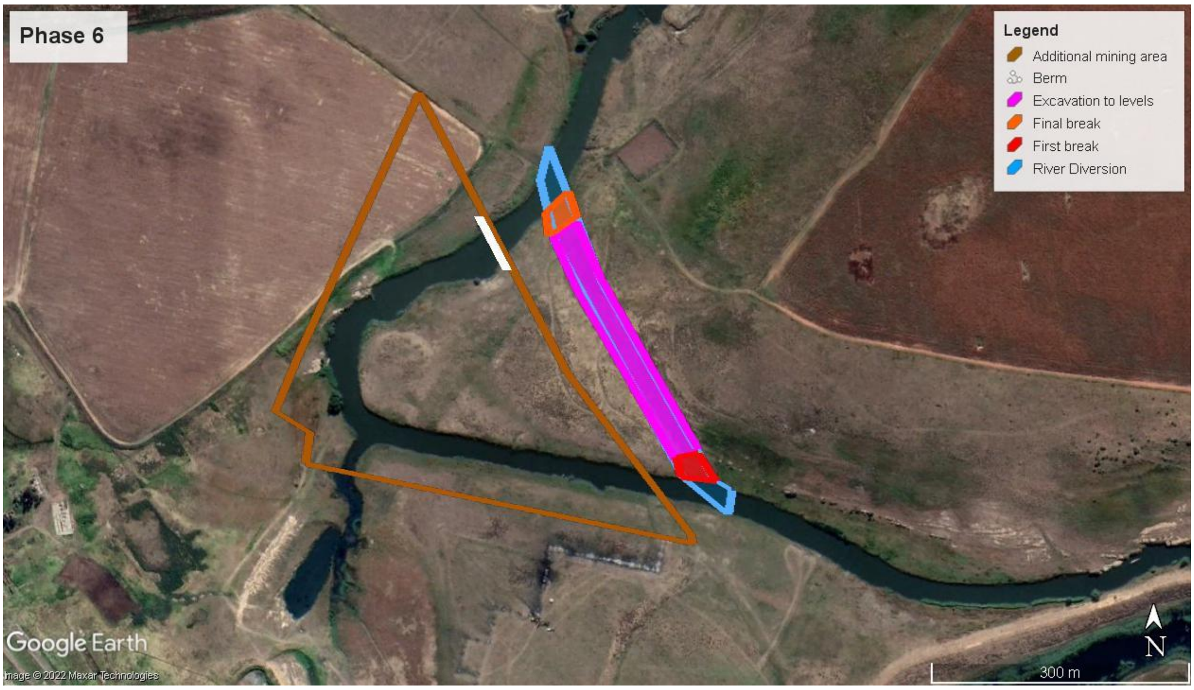

FIGURE 73: PHASE 6

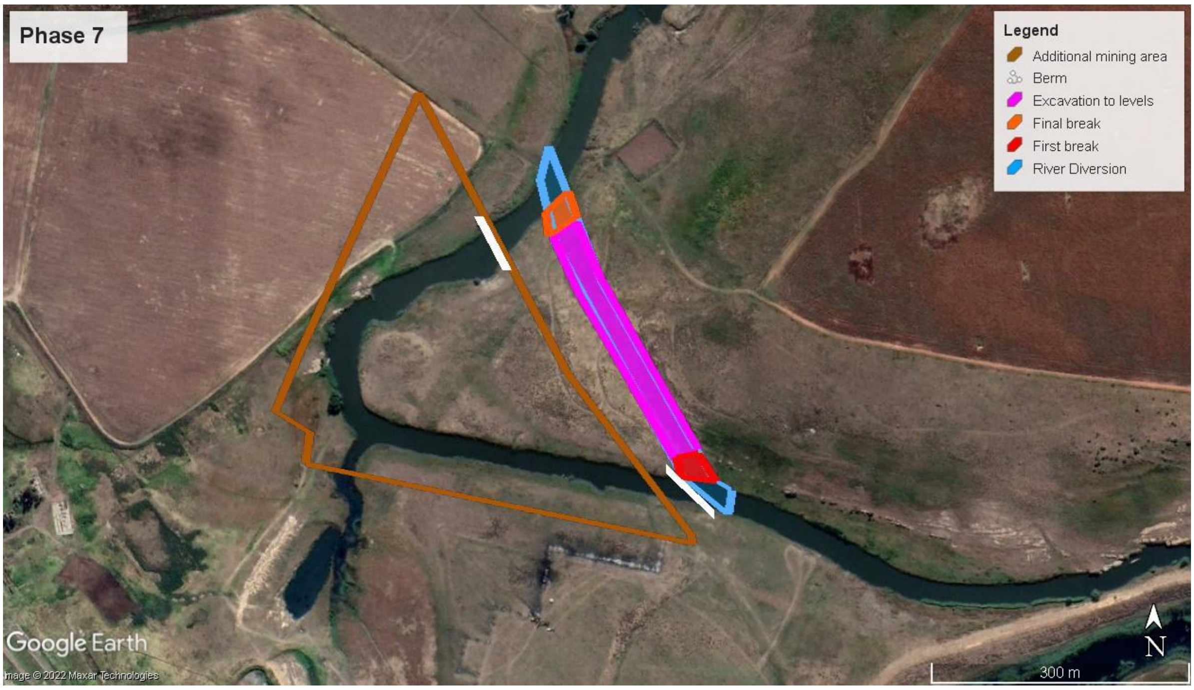

FIGURE 74: PHASE 7

7.3.7.Phase 8

Once both plugs are in place, pumping of water from the old channel can commence. It is of high importance that this phase be completed with the help of a team to facilitate the removal of aquatic fauna and flora with emphasis on fish from the drying channel to the new diversion. ***Exotic species cannot be moved and must be euthanised humanely.*** **This process needs to be driven by the AECO.**

7.3.8.Active mining

The area will be mined to predetermined levels. The EMP must guide this phase of the activity. Monitoring must take cognizance of the risk of AMD and must be designed to detect and mitigate such impacts.

7.3.9.Closure of mining/ rehabilitation

Once mining has been completed the area of mining must be rehabilitated. Currently (August 2022) a void will be created where mining took place. Water from the surrounding groundwater and surface water will infiltrate the area and pose an AMD risk. Phytoremediation of the sections must be investigated once the mining operations has completed. The areas of the diversion must be used as phytoremediation section. A series of dams must be created in the mining area to allow the decanting water to lay in the dams and evaporate (Figure 75 and Figure 76). The clays as expected from the old river bed must be removed and stockpiled separately for reuse in the ponds to create linings. Bentonite can be added to aid in sealing the ponds. The exact species composition must be determined on site by the aquatic specialist appointed for the project.

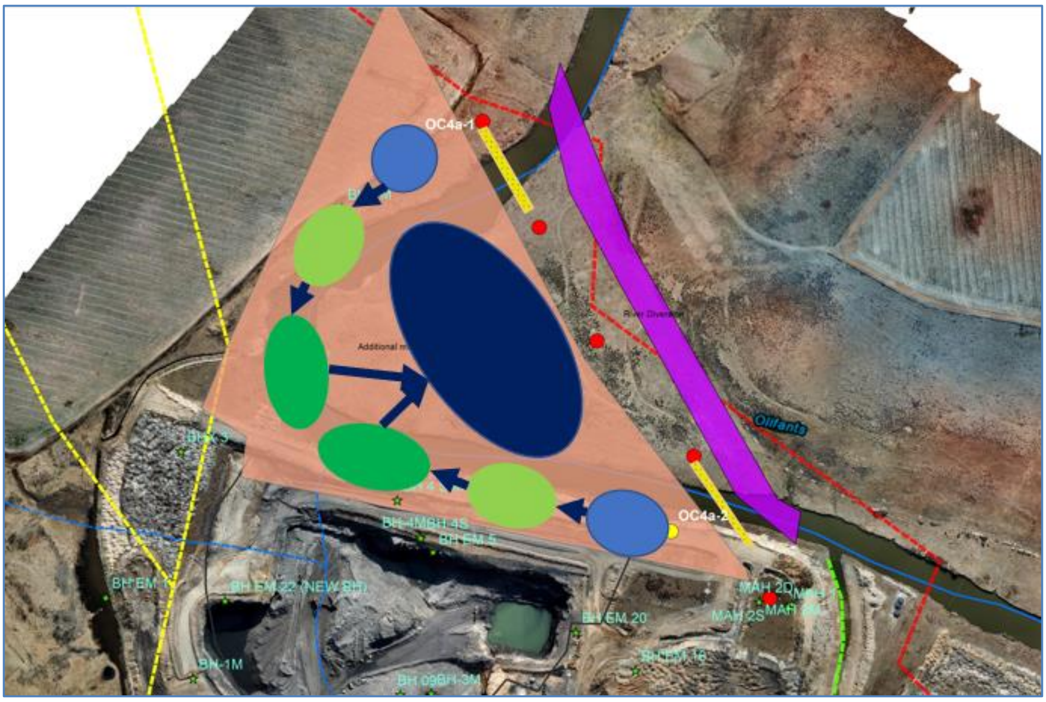

FIGURE 75: PROPOSED PHYTOREMEDIATION POND SYSTEM

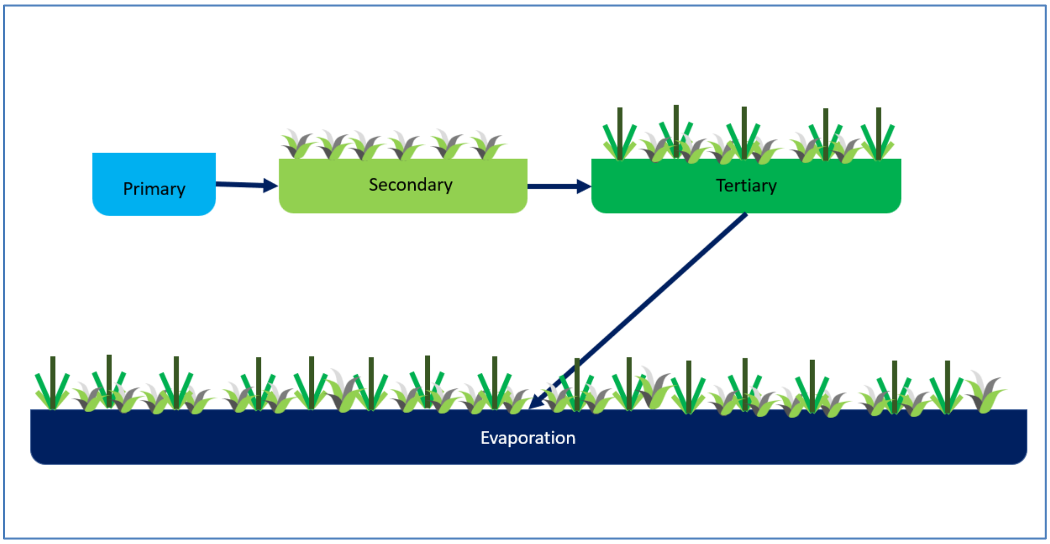

FIGURE 76: INTERNAL LAYOUT OF THE SERIES OF DAMS

7.4. Key Performance Indicators (KPI's) for phases

Key Performance Indicators for the various phases (1-7) and including Operational, Decommissioning, Closure, and post closure phases. These have been linked to relinquishment criteria for abandoning KPI's. See Table 51 for the KPI's and relinquishment criteria below. These KPI's are set based on expected impacts with expansion of the KPI's expected over time.

Table 51: Key Performance Indicators (KPI's) and relinquishment criteria's

Aspect	Key Performance Indicator				Relinquishment criteria			
	Preoperational phase	Operational phase	Closure phase	Post closure phase.	Preoperational phase	Operational phase	Closure phase	Post closure phase
Phase 1	All crew and personnel associated with the project receive training regarding work in and around the aquatic ecosystems.				Proof of training			
	All sensitive areas are demarcated until impacts are to occur in the systems.				Demarcations must remain in place throughout the phases			
	Authorisations in place	Review of authorizations	Review requirements with closure in mind	Close out certifications must be in place	No relinquished and will remain in place			
	Pre-impact monitoring and sampling completed.	Complete monitoring with review of pre-impact baseline results			No relinquished and will remain in place			
Phase 2	Stockpiling of topsoil is done in accordance with good practice	No alien vegetation establishment allowed Topsoil remains viable and is "living"	Will include the use of the topsoil.	No topsoil left and all was used for rehabilitation	N/A- topsoil monitoring required		Use of stockpile and will be relinquished if all topsoil is used	N/A
Phase 3	Reshaping of banks to emulate riparian area	Provides habitat	Continues to provide habitat	Continues to provide habitat	Signed off by AECO	Monitoring if habitat provision is occurring naturally	Habitat provisions stable and in place	Diversion becomes stable and habitat provision is in place. Natural hydrology is functional
Phase 4	Excavation and shaping of channel. Disposal of waste rock/ overburden done correctly	Hydrology is functional	Hydrology is functional without human intervention	Hydrology remains functional without human intervention	Signed off by AECO			
	Replanting of hydrophytes and other terrestrial areas as part of the diversion plan	Rehabilitation becomes established and propagates itself No alien vegetation	Climax state of flora. No Alien vegetation	Stable system functional without human interventions	Signed off by AECO and ECO			
Phase 5	Breakthrough of final section into the river- slow releases of water	Hydrology is functional	Hydrology is functional without human intervention	Hydrology is functional without human intervention	Signed off by AECO			

Aspect	Key Performance Indicator				Relinquishment criteria			
	Preoperational phase	Operational phase	Closure phase	Post closure phase.	Preoperational phase	Operational phase	Closure phase	Post closure phase
	with sediments managed							
Phase 6	Upper berm is installed	Berm remains functional			Signed off by AECO	N/A Remains in place		
Phase 7	Lower berm is installed							
Quantum/ Financial provision for closure or costings for rehabilitation	Review financial calculations annually	Reduction in expected costs	Reduction in expected cost.	NO additional costs required	Expenditure within calculations			NO additional costs required. Closure is self-supporting
Alien/ exotic vegetation	Zero expansion of alien vegetation	Zero expansion	Reduction in alien vegetation	Reduction in alien vegetation	Zero alien vegetation	Zero alien vegetation	Zero alien vegetation	Zero alien vegetation
Dewatering of open construction	Continuous	Continuous with reduction	Reduction to state of no dewatering	No dewatering required		Reduced pumping required	Reduction to state of no dewatering	Zero pumping required
Water quality	Zero expansion of pollution plume	Reduction in pollution plume	Reduction in pollution plume	Zero pollution	Return of water quality to normal standards	Return of water quality to normal standards	Return of water quality to normal standards	Return of water quality to normal standards
Review of KPI's	Annually by AECO and ECO				Annually by AECO and ECO			

8. Monitoring plan

It must be noted that monitoring is ongoing on site. The main goal of the monitoring is to assess the efficiency of the rehabilitation process and to ensure that the methods and phases of the rehabilitation process are implemented. Most importantly the monitoring program is conducted to detect if the proposed rehabilitation methods, as designed, are efficient and operational.

Due to the complexity of the rehabilitation process, it is proposed that a specialist Aquatic Environmental Control Officer (AECO) be on site for the duration of the process. This is advised as the possible impacts on the aquatic ecosystem are of such a concern that a trained person be instated for the full length of the diversion process and pre and post phases. This period length is at the discretion of the ECO, the Developer, and the AECO and the Department of Water Affairs as seen in the WUL (tbc when WUL has been received). The AECO will be tasked with the health of the aquatic ecosystems through the identification and mitigation of any environmental problems encountered and will have the power to stop any activities impacting negatively on the aquatic and terrestrial ecosystems. This must be in line with the current state of the environment and targets to improve on the state of the environment through rehabilitation.

To assign a timetable for the monitoring of the impacts is not achievable since the duration of the various periods are not known. It is therefore suggested that at the discretion of the AECO, the developer and the contractor, the timetable be decided on an adaptive time basis to adjust to the needs of the parties. It is proposed that a weekly inspection and reporting be conducted. It is important to ensure the correct aspects are adhered to during the monitoring of the site (Table 52). This is only recommended and may differ in the water use licence.

TABLE 52: ASPECTS AND MONITORING REQUIREMENTS OF THE STUDY SITE

ASPECT	MONITORING REQUIREMENTS
Baseline condition prior to the impact	This report
Aspects requiring monitoring	Water quality parameters (WQP) if possible, General diversion related impacts, SASS 5, Fish population assemblage,
Monitoring location	Up and downstream of the diversion, At the outlet from Mistake Lake

ASPECT	MONITORING REQUIREMENTS
Biomonitoring frequency	Six monthly/ Biannual
TWQR PARAMETERS	In situ as per Table 20
TWQR FREQUENCY construction	Monthly
TWQR FREQUENCY operational	Monthly
TWQR	As for aquatic ecosystems guideline by the Department of Water Affairs. Maximums can also be given in the WUL.
Responsible Party	Owner and construction company creating the diversion should appoint the AECO. Remediation work is the responsibility of the construction crews.
Frequency of Monitoring, and/or Timeframes	6 Monthly assessments of the Fish population, SASS 5 (or aquatic macroinvertebrate assessment)
Targets for Each Aspect Monitored	The mining should have a neutral impact on the system and thus the *in-situ* conditions
Photographic Record of Construction and Impacts	A fixed-point photographic record must be kept of the area. Reference images should be taken from a fixed point, before, during and after the construction.
Indicators for Measuring the Progress of Each Target	Water Quality: the indicators should not exceed the parameters set out in the in-situ conditions. Photographic image references: should be used based on visual observations of change
Environmental Driver Monitoring	Rainfall, temperature
Corrective Actions Implemented If Monitoring Is Not Progressive	As per the AECO monthly reports.

8.1. Monitoring reporting

8.1.1.Monitoring and timetable

The AECO will also be tasked with the following timetable (Table 53). Proper follow up programs for the eradication of alien vegetation are important. If the program neglects to do follow-ups the initial eradication work would be in vain, and the problem will increase in scale.

Table 53: Monitoring time table

Daily	- Ensure wetland areas outside the construction areas are not being unduly imposed on by construction activities or accessed by any means. - Ensure no species of fauna and flora is being utilized by the construction workers or destroyed. - Any reported problems to be inspected immediately and mitigating actions taken to ensure no prolonged damage occurs to the site. - Rainfall and temperature (can be provided by the construction crews).
Weekly	- Inspection of sedimentation traps. - Inspection of aquatic plants occupying the wetland areas to make sure the plants is not disturbed. - Inspection of aquatic plants removed and kept for later reintroduction, to ensure their health. If any problems are found with the plants a solution should be sought as soon as possible.
Monthly	- Monthly dated photographs should be taken from fixed high importance spots (marked on a map) and should be compared to the in-situ situation and if the need arises the correct mitigating actions should be taken. - Ensure environmental training of construction workers is up to date. - Report on the state of the environment during construction.

8.1.2.Reporting

Reporting frequency should be at the discretion of the AECO based on needs in terms of compliance, but no less than one report per week for all phases is recommended. See Table 54 for a reporting format on the impacts identified during this period. The water quality results should be indicated on a spreadsheet with date of sample, maximum and minimum TWQR and the results clearly indicated. If any major aspects occurred, such as high rainfall events, this must also be indicated. Photographic records of fixed points should include first image taken (before construction) and latest image on the same page for comparative ease.

TABLE 54: PROPOSED REPORTING FORMAT FOR THE WETLAND ECO

Activity	Comments	Action to be taken	Date for compliance	Action group	Frequency of action	Impact description	Penalty	Progress of reported impact

9. Conclusion and recommendations

The diversion of any aquatic ecosystem must not be taken lightly and is the most detrimental activity that can be undertaken by a developer. The exact location and magnitude of impacts are very difficult to assess- especially considering the dissolving effect of impacts in water and the transportation of the impact from the impact area to a secondary location.

The monitoring of the rehabilitation process is of paramount importance to ensure the efficiency thereof. If rehabilitation does not occur as stipulated, then corrective measures must be enforced through the audit findings and reports. Communication between the rehabilitation implementer, the author of the rehabilitation plan, the developer, and the construction contractor is of principal importance to ensure execution of the rehabilitation plan. If any areas of concern are found, then they must be explored to determine the extent of and solution to the problem.

Due to the complexity of the rehabilitation process, it is proposed that a specialist Aquatic Environmental Control Officer (AECO) be on site for the duration of the process. This is advised as the possible impacts on the aquatic ecosystem are of such a concern that a trained person be instated for the full length of the diversion process and pre and post phases.

9.1. Go/ No go

Many years of mining on site and in the catchment has reduced the condition of the aquatic ecosystems on site. The risk of acid mine drainage will increase each year of operation. The diversion of the river system as proposed will decrease this risk and remove the coal creating AMD conditions. It is important that the activity on site is monitored by a suitably qualified (SACNASP register in the field of aquatic sciences) aquatic ecologist on a quarterly basis to ensure non- and stochastic events and impacts are mitigated. If the proposed management and mitigation measures are incorporated in addition with the rehabilitation plan the project can be supported by the author.

9.2. Environmental laws

The following environmental laws could be applicable to the study site. These are only recommendations and to ensure compliance, a lawyer specialising in environmental law should be consulted:

- National Environmental Management Act, 1998 (Act No. 107 of 1998)
- The National Water Act, 1998 (Act No. 36 of 1998) with specific reference paid to Section 21 of the National Water Act, 1998 (Act No.36 of 1998)

- The National Water Act, 1998 (Act No. 36 of 1998) General Notice 1199 - development within 500 meters of a wetland
- The National Water Act, 1998 (Act No. 36 of 1998) General Notice 1198 - Rehabilitation of a wetland area
- Regulation No. 543 – 545, 2010 of the National Environmental Management Act, 1998 (Act No. 107 of 1998)
- National Environment Management Protected Areas Act, 2003 (Act No. 57 of 2003).
- National Environment Management Waste Act, 2008 (Act No. 59 of 2008).
- National Veld and Forest Fire Act, 1998 (Act No.101 of 1998).
- Mountain Catchment Act, 1970 (Act No. 63 of 1970).
- National Heritage Recourses Act, 1999 (Act No. 25 of 1999).
- World Heritage Convention Act, 1999 (Act No. 49 of 1999).
- Municipal Systems Act, 2000 (Act No. 32 of 2000).
- Integrated Coastal Management Act, 2008 (Act No. 24 of 2008).
- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983).
- Land Use Planning Ordinance 15 of 1985 and the planning ordinances depending on the province in South Africa where construction will take place

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11. Appendix A: Glossary of terms:

Buffer zone- The area of land next to an aquatic ecosystem, where activities such as construction are restricted to protect said systems.

Detritus- Decaying organic matter found in the top layer of soil or mixed with wetland waters, a food source for many small wetland organisms.

Endangered species- Any species of plant or animal that is having trouble surviving and reproducing. This is often caused by loss of habitat, not enough food, or pollution. Endangered species are protected by the government to keep them from becoming extinct.

Ecosystem- A network of plants and animals that live together and depend on each other for survival.

Emergent- Soft stemmed plants that grow above the water level.

Erosion- Process in which land is worn away by external forces, such as wind, water, or human activity.

Freshwater- Water without salt, like ponds and streams.

Gleyed soil- Mineral wetland soil that is or was always wet; this results in soil colours of grey, greenish grey, or bluish grey.

Habitat- The environment in which an organism lives.

Hydric soil- Soil that is wet long enough for anoxic (oxygen less) conditions to develop. The water in the soil forces air out. This soil type is found in wetlands.

Hydrocarbon Oils, fuels and paints made using fossil fuels (including crude oils, coal etc.)

Hydrophyte- A plant, which grows in water.

Mesotrophic soil- Soils with a moderate inherent fertility. An indicator of soil fertility is its base status, which is expressed as a ratio relating the major nutrient cations (calcium, magnesium, potassium, and sodium) found there to the soil's clay percentage.

Organic material- Anything that is living or was living; in soil it is usually made up of nuts, leaves, twigs, bark, etc.

Organism- A living thing.

Peat- Organic material (leaves, bark, nuts) that has decayed partially. It is dark brown with identifiable plant parts and can be found in peatlands and bogs.

Pollution- Waste, often made by humans, that damages the water, the air, and the soil.

Precipitation- Rain, sleet, hail, snow.

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

Redoximorphic conditions- a soil property, associated with wetness, which results from the reduction and oxidation of iron and manganese compounds in the soil after saturation with water and desaturation, respectively. Mottling are common redoximorphic features of soils.

Runoff- Rainwater that flows over the land and into streams and lakes; it often picks up soil particles along the way and brings them into the streams and lakes.

Salinity- The amount of salt in water.

Saturation-The condition in which soil contains as much water as it can hold.

Silt- One of three main parts of soil (sand, silt, and clay); silt is small rock particles that are between .05 mm and .002 mm in diameter.

Submerged aquatic vegetation- Plants that live entirely under water.

Top soil- The top layer of soil; it is full of organic material and good for growing crops.

Water table- The highest level of soil that is saturated by water.

Watershed - All the water from precipitation (rain, snow, etc.) that drains into a particular body of water (stream, pond, river, bay, etc.)

Wetland- Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

12. Appendix B: Acronyms

AECO	Aquatic Environmental Control Officer
ASPT	Average Score Per Taxon
CERM	Comprehensive Ecological Reserve Methodology
DSS	Decision Support System
DWA	Department of Water Affairs
DWS	Department of water and sanitation
EC	Ecological Category
ECO	Environmental control officer
EIS	Ecological Importance and Sensitivity
EWR	Environmental Water Requirements
FRAI	Fish Response Assessment Index
FROC	Fish reference of occurrence
GSM	Gravel, Sand, Mud
GDARD	Gauteng Department of Agriculture and Rural Development
IERM	Intermediate Ecological Reserve Methodology
IHAS	Invertebrate Habitat Assessment System
IHI	Index of Habitat Integrity
MIRAI	Macro-Invertebrate Response Assessment Index
MVIC	Marginal Vegetation in Current
MVOOC	Marginal Vegetation out of Current
NFEPA	National Freshwater Ecosystem Priority Areas
PES	Present Ecological State
REC	Recommended Ecological Category
REMC	Recommended Ecological Management Class
RERM	Rapid Ecological Reserve Methodology
RHP	River Health Programme
SASS5	South African Scoring System (Version 5)
SIC	Stones in current

SOG	Soap, oil and grease
SOOC	Stones out of current
TPH	Total petroleum hydrocarbons
TWQR	Target water quality range
VEGRAI	Vegetation Response Assessment Index
Wetland IHI	Wetland index of habitat integrity tool
WMA	Water Management Area
WUL	Water use licence (approved license)
WULA	Water use licence application (license application)