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Wetland flow driver assessment

for

OC4A _ 2 Seam Mining

Compiled for:

Elemental Sustainability Pty Ltd

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Compiled By:	S. C. Nkosi; M. Sc.; Cand. Sci. Nat (100105/13)
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NEMA Regs (2014) - Appendix 6	**Relevant section in report**
Details of the specialist who prepared the report	Page i
The expertise of that person to compile a specialist report including a curriculum vitae	Page i
A declaration that the person is independent in a form as may be specified by the competent authority	Page i
An indication of the scope of, and the purpose for which, the report was prepared	Detailed in report
The date and season of the site investigation and the relevance of the season to the outcome of the assessment	Detailed in report
A description of the methodology adopted in preparing the report or carrying out the specialised process	Detailed in report
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Detailed in report
An identification of any areas to be avoided, including buffers	Detailed in report
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Detailed in report
A description of any assumptions made and any uncertainties or gaps in knowledge;	Detailed in report
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Detailed in report
Any mitigation measures for inclusion in the EMPr	Detailed in report
Any conditions for inclusion in the environmental authorisation	Detailed in report
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Detailed in report
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and	Detailed in report
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	
A description of any consultation process that was undertaken during the course of carrying out the study	N/A
A summary and copies if any comments that were received during any consultation process	N/A
Any other information requested by the competent authority	N/A

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Explanation
ARD	Acid Rock Drainage
BPG	Best Practice Guidelines
CMS	Catchment Management Strategy
CSM	Conceptual Site Model
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
IWRMP	Integrated Water Resources Management Plan
IWRM	Integrated Water Resources Management
km^2	Square kilometre
L/s	Litres per second
mamsl	Metres above mean sea level
Ml/d	Megalitres per day
m	metre
mm	Millimetre
mm/a	Millimetres per annum
mS/m	Millisiemens per metre
m^3	Cubic metre
MAP	Mean Annual Precipitation
MPRDA	Mining and Petroleum Resources Development Act (Act No. 73 of 2002) 1989)
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NWA	National Water Act (Act No. 36 of 1998)
ppm	Parts per million
RDM	Resource Directed Measures
RQO	Resource Quality Objective
RWQO	Resource Water Quality Objective
TDS	Total Dissolved Solids
WMA	Water Management Area
WMP	Water Management Plan

DEFINITIONS

Definition	Explanation
Aquiclude	A geologic formation, group of formations, or part of formation through which virtually no water moves
Aquifer	A geological formation which has structures or textures that hold water or permit appreciable water movement through them. Source: National Water Act (Act No. 36 of 1998).
Borehole	Includes a well, excavation, or any other artificially constructed or improved underground cavity which can be used for the purpose of intercepting, collecting or storing water in or removing water from an aquifer; observing and collecting data and information on water in an aquifer; or recharging an aquifer. Source: National Water Act (Act No. 36 of 1998).
Boundary	An aquifer-system boundary represented by a rock mass (e.g., an intruding dolerite dyke) that is not a source of water, and resulting in the formation of compartments in aquifers.
Cone of Depression	The depression of hydraulic head around a pumping borehole caused by the withdrawal of water.
Confining Layer	A body of material of low hydraulic conductivity that is stratigraphically adjacent to one or more aquifers; it may lie above or below the aquifer.
Dolomite Aquifer	See “Karst” Aquifer
Drawdown	The distance between the static water level and the surface of the cone of depression.
Fractured Aquifer	An aquifer that owes its water-bearing properties to fracturing.
Groundwater	Water found in the subsurface in the saturated zone below the water table.
Groundwater Divide or Groundwater Watershed	The boundary between two groundwater basins which is represented by a high point in the water table or piezometric surface.
Groundwater Flow	The movement of water through openings in sediment and rock; occurs in the zone of saturation in the direction of the hydraulic gradient.
Hydraulic Conductivity	Measure of the ease with which water will pass through the earth's material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (m/d).
Hydraulic Gradient	The rate of change in the total hydraulic head per unit distance of flow in a given direction.
Infiltration	The downward movement of water from the atmosphere into the ground.
Intergranular Aquifer	A term used in the South African map series referring to aquifers in which groundwater flows in openings and void spaces between grains and weathered rock.
Karst (Karstic)	The type of geomorphological terrain underlain by carbonate rocks where significant solution of the rock has occurred due to flowing groundwater.

Definition	Explanation
Karst (Karstic) Aquifer	A body of soluble rock that conducts water principally via enhanced (conduit or tertiary) porosity formed by the dissolution of the rock. The aquifers are commonly structured as a branching network of tributary conduits, which connect together to drain a groundwater basin and discharge to a perennial spring.
Monitoring	The regular or routine collection of groundwater data (e.g., water levels, water quality and water use) to provide a record of the aquifer response over time.
Observation Borehole	A borehole used to measure the response of the groundwater system to an aquifer test.
Phreatic Surface	The surface at which the water level is in contact with the atmosphere: the water table.
Piezometric Surface	An imaginary or hypothetical surface of the piezometric pressure or hydraulic head throughout all or part of a confined or semi-confined aquifer; analogous to the water table of an unconfined aquifer.
Porosity	Porosity is the ratio of the volume of void space to the total volume of the rock or earth material.
Production Borehole	A borehole specifically designed to be pumped as a source of water supply.
Recharge	The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.
Recharge Borehole	A borehole specifically designed so that water can be pumped into an aquifer in order to recharge the ground-water reservoir.
Saturated Zone	The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.
Specific Capacity	The rate of discharge from a borehole per unit of drawdown, usually expressed as m3/d•m.
Specific Yield	The ratio of the volume of water that drains by gravity to that of the total volume of the saturated porous medium.
Storativity	The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.
Transmissivity	Transmissivity is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.
Unsaturated Zone (Also Termed Vadose Zone)	That part of the geological stratum above the water table where interstices and voids contain a combination of air and water.
Watershed (Also Termed Catchment)	Catchment in relation to watercourse or watercourses or part of a watercourse means the area from which any rainfall will drain into the watercourses or part of a watercourse through surface flow to a common point or points. Source: National Water Act (Act No. 36 of 1998).
Water Table	The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is equal to that of the atmosphere.

1 INTRODUCTION

Geo Pollution Technologies (Pty) Ltd (GPT) was appointed by Elemental Sustainability (Pty) Ltd (Elemental) to conduct a wetland flow driver (hydropedological assessment) for opencast mining on the farm Vlaklaagte known as OC4 (existing opencast) and the proposed river diversion of the Olifants river to accommodate further opencast mining (OC4A) as shown in Figure 1. The focus of this report is the potential impact from the proposed opencast mining (OC4A) and TSF not assessed in the previous study:

- Wetland flow driver assessment for OC4 (October 2020)

It should be noted from the outset that hydropedology focuses on wetland impacts feeding the Olifants river and does not address direct groundwater and surface water impacts related to diverting the Olifants river which requires specialist studies. Hydropedological surveys aim to characterise dominant surface and sub-surface flow paths of water through the landscape to wetlands and streams or groundwater.

1.1 Normative references

The following normative references are indispensable to this report as it contains information used in terms of wetland flow:

- Eco Elementum, November 2018 - Water balance update and pollution control dam status quo - REPORT REF: 19-799C-SW
- Galago Environmental, September 2020 - Aquatic ecosystem mitigation plan for the Vlaklaagte North block 2 on portions of the farm VLAKLAAGTE 45 IS.
- Luhlaza Advisory and Consulting (Pty) Ltd, October 2020 - Report to Elemental Sustainability on the results of a geotechnical investigation in support of the WULA for 2 Seam Colliery in Mpumalanga Province - LC036-20. R01
- GCS (Pty) Ltd, August 2022 - Geohydrological Assessment for the proposed 2-Seam (Pty) Ltd Vlaklaagte Mine River Diversion. GCS Project Number: 22-0619

2 GEOGRAPHICAL SETTING

2.1 Site Location, Topography and Drainage

The site layout shown in Figure 1 below is typical of the developed agricultural and mining area within Mpumalanga with most of the catchment area consisting of mining activity and farm lands with the Olifants river and wetland sections being the main surface water feature. The contributing catchment starts just north of the town of Bethal and pass just to the west of Hendrina and to the east of Kriel. The site is located directly to the east of the R544 and to the south of the R542. Water drains from the area in a northernly direction towards the Olifants river.

There are two water courses flowing through the site (see Figure 2 below). The first is the Olifants river on the northern border of the site and the second a minor flow area creating the channelled valley bottom flowing into the Olifants river. The wetland catchment drains mainly from the south in a northernly direction until it reaches the Olifants river. The highest point of the wetland catchment is in the north with an approximate level of 1,600 mamsl and the lowest point at the site is 1,535 mamsl.

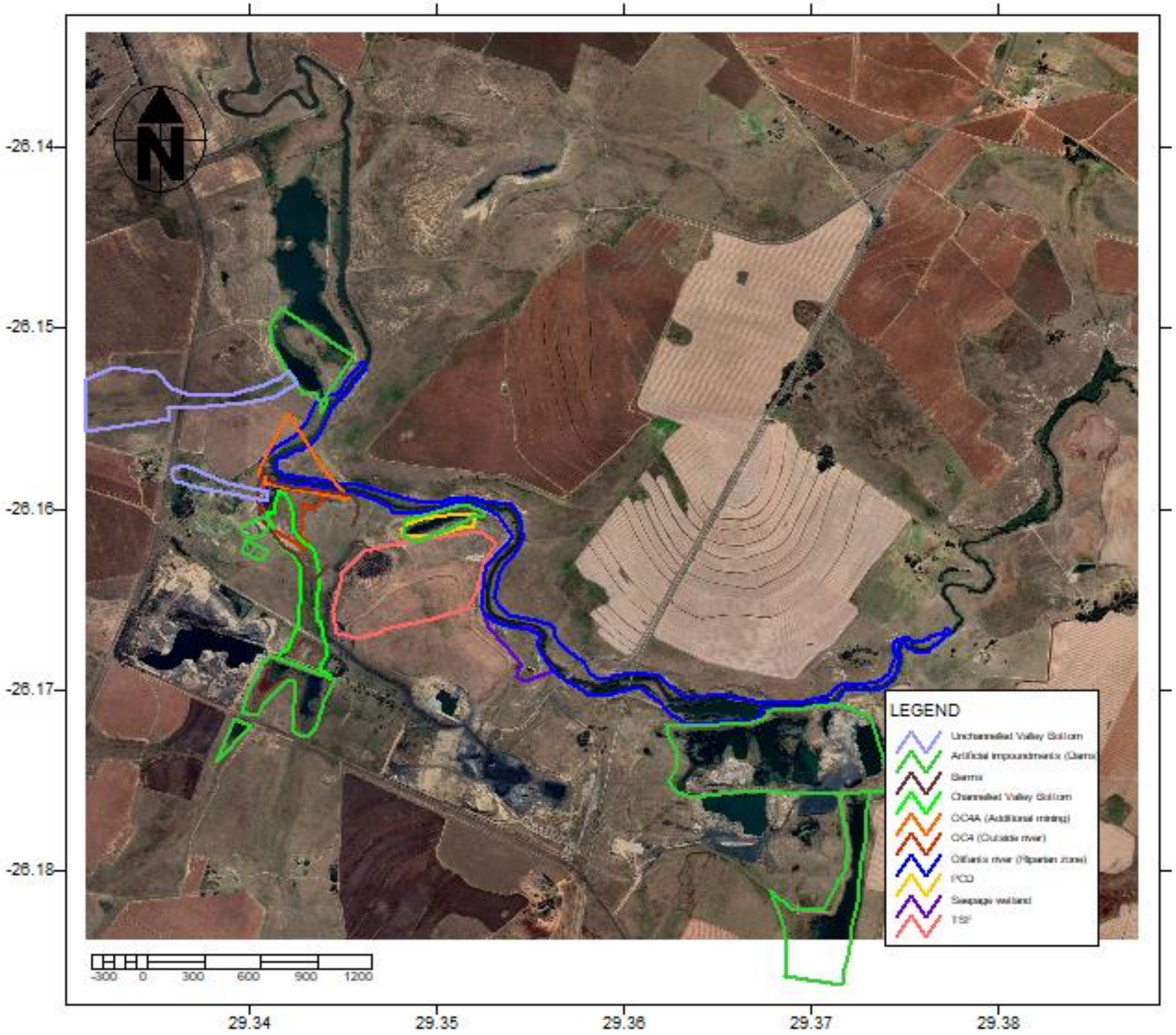

Figure 1: Site Layout

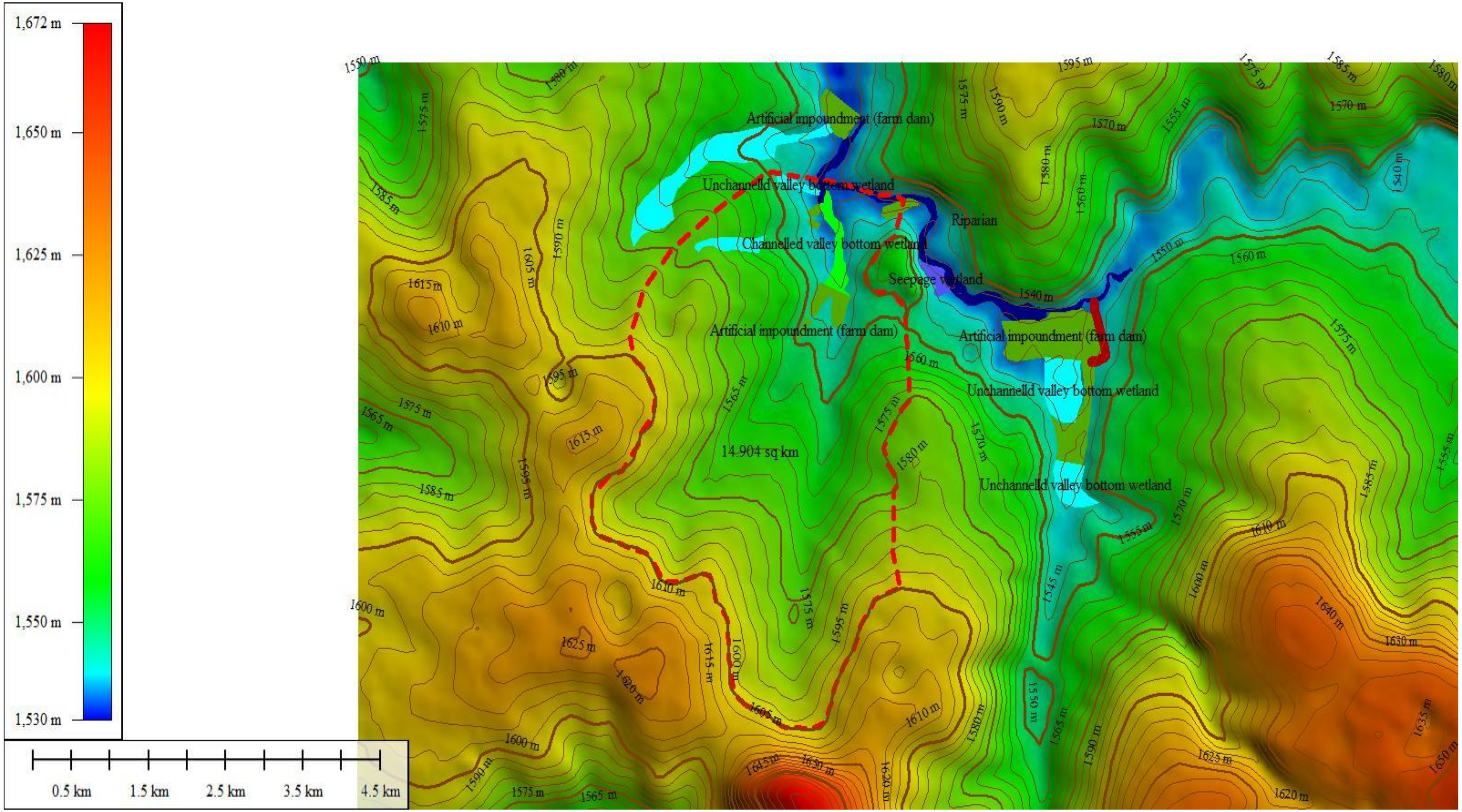

Figure 2: Site drainage and topography

2.2 Climate

Climatic data was obtained from the DWS weather station VANDYKSDRIFT Weather Station (0478546_W). The Mean Annual Precipitation (MAP) is reported as 679 mm per annum. In terms of flood peak calculations, the Design rainfall estimation in South Africa program was used to calculate the MAP for the site, and a slightly higher value of 690 mm was adopted for the calculations.

3 PREVIOUS FINDINGS

The following reports are applicable to this study and are referenced below. A short summary if information pertaining to the wetland flow driver assessment is also detailed:

Luhlaza Advisory and Consulting (Pty) Ltd, October 2020 - Report to Elemental Sustainability on the results of a geotechnical investigation in support of the WULA for 2 Seam Colliery in Mpumalanga Province - LC036-20. R01

Five test pits were excavated at selected points within the site boundary. The test pits have been designated by prefixes TP01 to TP05 and were excavated using a TLB to approximate refusal depths in the range 0.9m (TP03) to 2.8m (TP05) below existing ground level (begl).

No groundwater was encountered in the test pits. However, as the site is close to a stream the risk for an elevated groundwater condition is considered to be high particularly in view of the proposed excavation activity which is approximately 5m begl.

The ground conditions identified within the site are inferred based on actual field test positions and are likely to variate.

The subsurface soil profile comprises sandy to gravelly fill, alluvial, colluvial, residual material and weathered sandstone rock.

Groundwater seepage was not encountered in any of the test pits excavated on site. However, the risk for an elevated groundwater condition is high.

Galago Environmental, September 2020 - Aquatic ecosystem mitigation plan for the Vlaklaagte North block 2 on portions of the farm VLAKLAAGTE 45 IS.

The Olifants River is deep (>1.5 meters) with steep banks and a narrow marginal zone. The active channel in the system is wide, with Salix micronata in many places on the riparian zones (Riparian, PES Category C, REMC - High) of the river banks.

The impoundments to the west of the site are of low concern. Mining activities has completely transformed the system and the functions and composition of the old valley bottom wetland have been lost. 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).

A single channelled valley bottom wetland (PES Category D (largely modified), REMC – Moderate condition) was observed on site. The system feeds directly into the Olifants River and is fed from an unchanneled valley bottom wetland. 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 unchanneled valley bottom wetland feeding into the single channelled valley bottom wetland (PES Category C, REMC – Moderate) is impacted by impoundments. This directly influences the hydrology of the channelled valley bottom wetland.

Eco Elementum, November 2018 - Water balance update and pollution control dam status quo - REPORT REF: 19-799C-SW

The maximum evaporation rate occurs in January, with a mean rate of 5.3 mm per day. Evaporation is greater than rainfall for all months of the year resulting in a marked moisture deficit in the region.

Mine planning indicated OC4 could only be mined if a river diversion is done. There are currently no dirty areas contributing to contaminated runoff.

GCS (Pty) Ltd, August 2022 - Geohydrological Assessment for the proposed 2-Seam (Pty) Ltd Vlaklaagte Mine River Diversion. GCS Project Number: 22-0619

The mining of OC4 is predicted to affect the Olifants River and subsequent aquifer, by inducing a 0.5 to 1 m drawdown of the subsequent aquifer zone. Therefore, just before the stream diversion takes place, there may be baseflow loss from the Olifants River segment. After the proposed diversion takes place, a drawdown ranging from 32 to 20 mbgl, with a greater drawdown towards the south of OC4, is predicted. Because the Olifants River is diverted, a new flow regime is established. The predicted impact on the diverted flow area is < 2 m, and the stream diversion area appears to be safe from the dewatering associated with the OC4A expansion. The groundwater flow system along the Olifants River that will be diverted is predicted to change significantly. Groundwater baseflow and groundwater recharge resulting from the presence of the Olifants River will decrease along OC4 & OC4A, and a long-term dewatering zone is predicted because the natural hydraulic boundary conditions changes if the Olifants River is diverted. It is important to calibrate the numerical model during the opencast expansion, and if the diversion is approved, more boreholes should be drilled in the area to refine and calibrate the groundwater flow fields. Based on the analytical estimates a rebound of the opencast working is expected between 18 to 47 years, however, the numerical model that considers aquifer flow and baseflow suggests a longer rebound due to the stream diversion.

The proposed diversion, from a geohydrological perspective, seems feasible, in context with the limitations and risks identified in this assessment.

4 SITE VISIT AND OBSERVATIONS

A site visit was done on 5 October 2022 with land use surrounding the wetlands mostly cultivated land (maize), grazing and mining. Significant channel erosion has occurred within some of the valley bottom wetlands.

Steep sandstone embankments > 45 degrees were observed on the edges of the Olifants river, with berms and wetland diversion in place surrounding the existing opencast (OC4) south of the Olifants river. The site photos are shown in Figure 3 below.

Figure 3: Site photos (5 October 2022)

5 IDENTIFICATION OF DOMINANT HILLSLOPES

The wetlands are dominated by extensive hillslope seepage and unchanneled valley bottom wetlands that feed into the valley bottom wetlands associated with the Olifants river. Precipitation first strikes vegetative surfaces before hitting the soil. Depending on the humidity within the canopy, a certain amount of the water temporarily sorbed onto vegetative surfaces evaporates before moving to the soil.

The amount of water is the ratio of vegetative surface area to the underlying ground surface area. Leaf area indices range from as little as 1.0 for short grasses and desert scrub, around 3.0– 4.0 for grasslands and savannahs.

Infiltration is the movement of water into the soil, and the hydrology and water quality of a watershed is controlled to a large degree by the infiltration characteristics of the surface soils. Although infiltration rates in wetlands themselves are typically low, infiltration rates across the landscapes surrounding wetlands can have a strong effect on the routing of water to the wetlands. Water infiltrates into the soil and enters the vegetative root system to be used in evapotranspiration, travels by subsurface pathways to surface waters (streams, wetlands) found at the base of slopes, or percolates to groundwater. Human land-use activities that compact or denude soils reduce infiltration rates, often reducing them so much they are exceeded by commonly experienced rainfall. When rainfall rates exceed infiltration rates, the excess water runs off the soil surface, rapidly carrying sediment and contaminants to surface waters and increasing storm flows. Maintenance of good hydrologic and water-quality conditions in surface waters is largely a matter of maintaining high infiltration rates. The physics of infiltration are very complicated. Infiltration rates in soils are affected by soil physical properties (porosity, structure, and texture, discussed above), antecedent moisture content, the amount of `vegetative detritus on the soil surface, vegetation, layering of soils, vertebrate and invertebrate activity in the topsoil, landscape position, groundwater dynamics, and even air temperature. For given soil conditions, the potential infiltration rate decreases asymptotically over time during a wetting event thus only indicative modelling can be done.

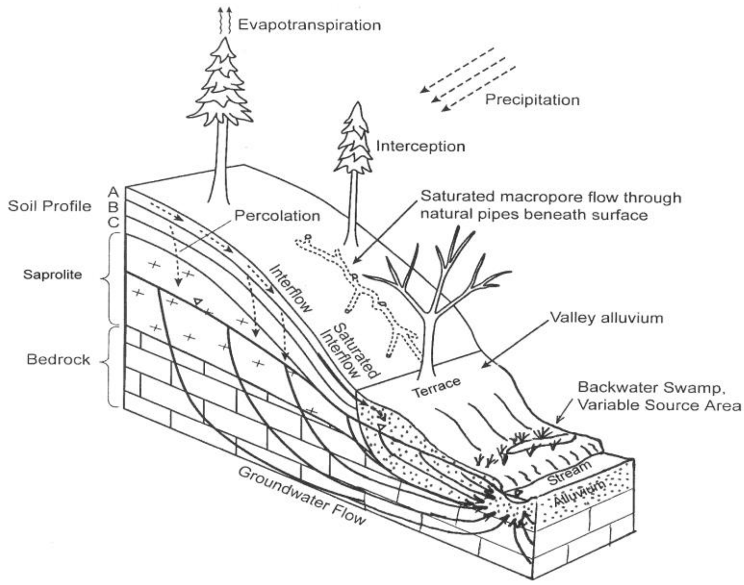

Figure 4: Conceptual understanding[1]

5.1 Surface runoff

The study area is located in the upper Olifants River Catchment and is typical of the interior of South Africa on the Highveld region of Mpumalanga Province. The site is found in Quaternary Catchment B11B and within the Olifants Water Management Area (WMA 4).

Runoff from natural (unmodified) catchments in this area is simulated in WR2012 as being equivalent to 48.57 millimetres per year over the surface area and is equal to approximately 7.07% of the Mean Annual Precipitation (MAP). Runoff within the Blocks was simulated considerably higher at~64% of MAP. It is expected that runoff from the mine site (TSF, office, etc) will be similar to the runoff expected within Blocks.

For the TSF within the area, a different runoff pattern is likely to occur at ~69% MAP. Water will seep into surfaces more easily and will be held in temporary storage before being released at a more constant rate.

5.2 Conceptualize hillslope hydro-pedological responses

Auger holes and test pits were done to delineate the soils and are described below. Bucket augers were done at selected points the area of OC4A only. A summary of the soil types is discussed below. In Figure 5 an attempt to delineate the soils hydro-pedologically was made using available desktop information, site visits and transect information. Note that the responsive and interflow soils were grouped together as it was difficult to accurately delineate this transition zone.

5.2.1 Recharge soils

The sandy soils are generally shallow and overlie an impeding sandstone layer. The main soil forms found in rocky soils were Mispah. These soils were the dominant soil type at OC4A north of the Olifants river.

[1] Wetland Soils, Hydrology, and Geomorphology C. RHETT JACKSON, JAMES A. THOMPSON, and RANDALL K. KOLKA

5.2.2 Interflow or transitional soils

The transitional soil unit comprises the soils found between clay soils and the agricultural soils. These soils often have signs of clay accumulation or water movement in the lower horizons. These soils are usually indicative of seasonal or temporary wetland conditions. No interflow soils were found at the at OC4A north of the Olifants river.

5.2.3 Responsive soil

This soil form is most commonly found in areas of semi-permanent wetness. No responsive soils were found at OC4A north of the Olifants river.

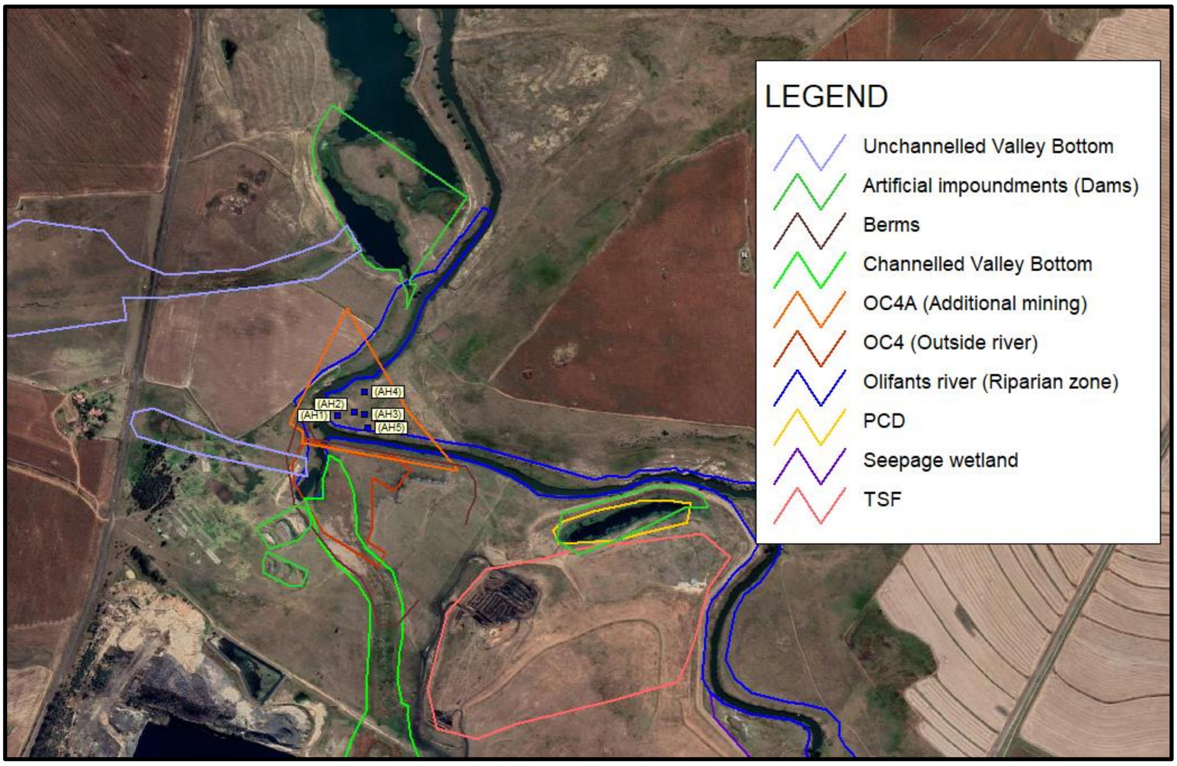

Figure 5: Auger hole positions

Figure 6: Auger hole photos (Recharge soils)

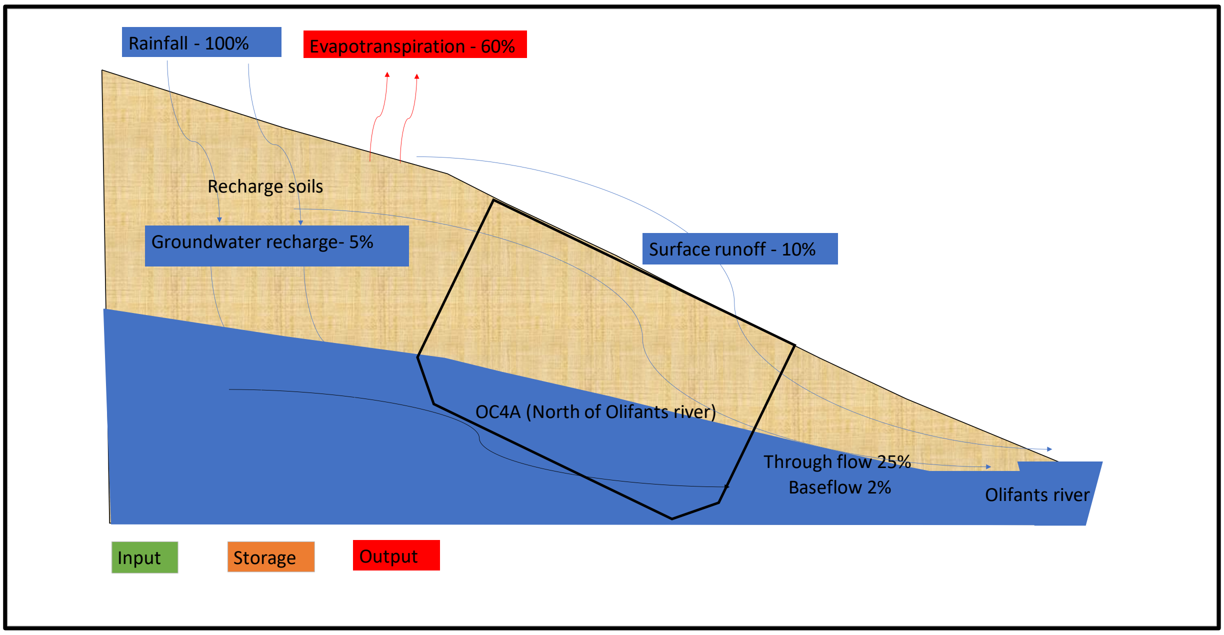

Figure 7: Conceptual site model

5.3 Quantification of hydraulic properties and flowrates.

Quantification of hydraulic properties was done through the following:

1. In situ field infiltration tests;
2. Falling head permeability tests;
3. Wetland delineation; and,
4. Site observations.

An interpolated map of the hydro pedological soil types based on the above is detailed Figure 8 below.

5.3.1 In situ infiltration tests

In situ infiltration tests (falling head permeability test) to estimate the rate at which runoff will infiltrate, or pass through the soil profile were done as follows:

Step 1: Test hole with the following dimensions Depth 50 cm, Diameter 10 cm

Step 2: Determine soil texture through a ribbon test

Step 3: Fill the hole with water and measure time to drain the hole completely

Step 4: Calculate the infiltration rate using the following formula

$$k = \frac{2.3A}{F(t_2 - t_1)} \log \frac{h_1}{h_2}$$

A summary of the soil results from the auger holes are shown in Table 1 below. The following observations can be made regarding the permeabilities:

- The majority of the samples are typical recharge soils without any morphological indication of saturation. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow direction.

Table 1: Auger hole infiltration rates

Label	m/s	% Clay	% Silt	% Sand	% Gravel		Material Description
AH1	1.19-06	2	12	78	8	100	SANDY GRAVEL
AH2	1.22-06	1	15	75	9	100	SANDY GRAVEL
AH3	1.21-06	2	14	76	8	100	SANDY GRAVEL
AH4	1.17-06	3	15	73	9	100	SANDY GRAVEL
AH5	1.29-06	3	12	75	10	100	SANDY GRAVEL

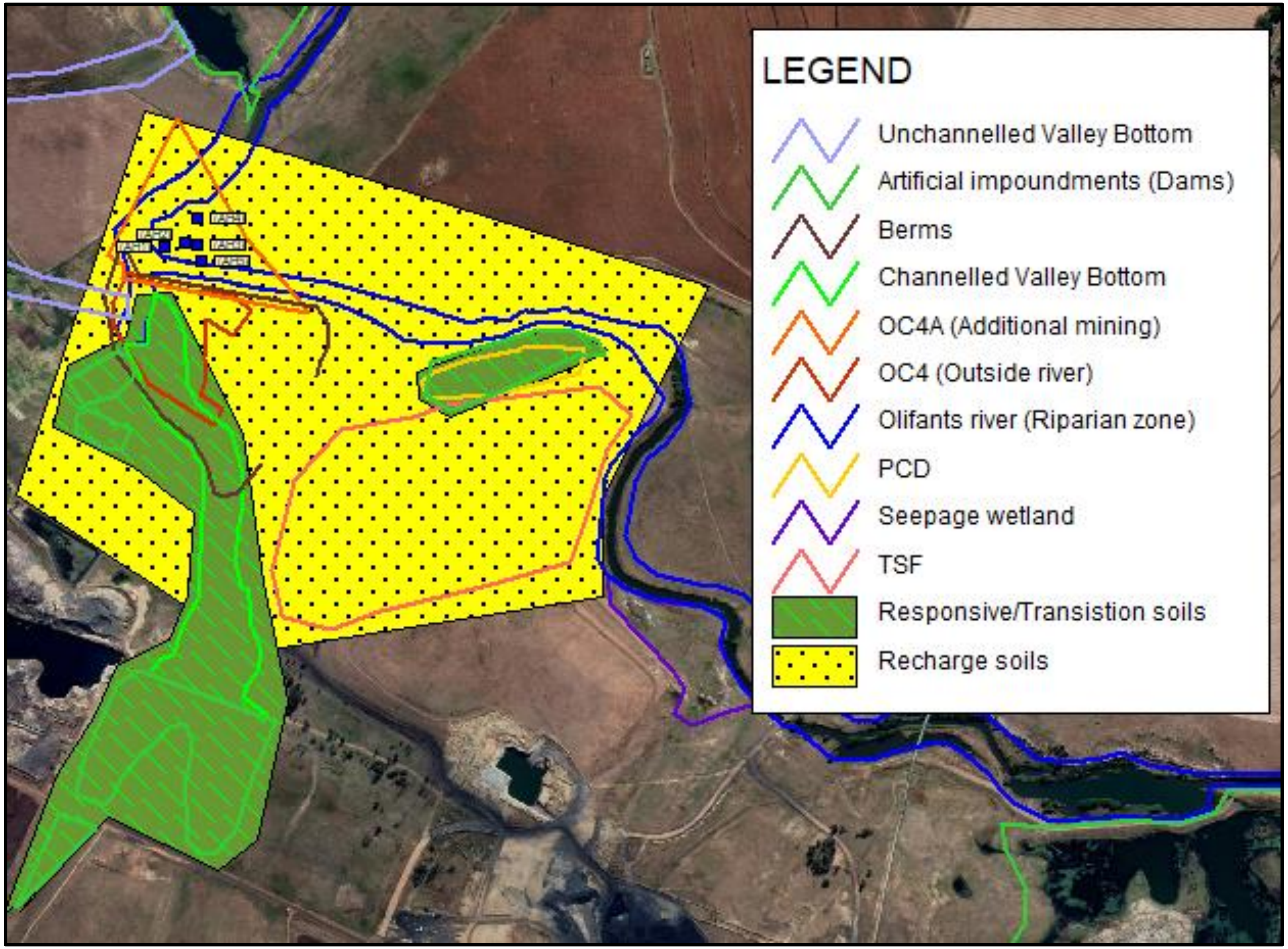

Figure 8: Interpolated hydropdeological soil types

6 WETLAND FLOW DRIVER IMPACT

OC4 and OC4A (river diversion extension) could impact on the flow drivers of the wetland systems through interception systems such as drainage systems, berms, increased recharge and water quality changes. The test pits indicated different hydropedological soil types comprising of alluvial, colluvial, residual material and weathered sandstone rock.

6.1 Wetland catchment flow reduction

The SANBI Biodiversity Series 22, (2013) Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems was consulted in determining the estimated flow losses to the specific wetland catchment systems due to mining.

Many wetlands are hydrologically and ecologically linked to adjacent groundwater bodies, but the degree of interaction can vary greatly. Some wetlands may be completely dependent on groundwater discharge under all climatic conditions, whilst others may have very limited dependence such as only under very dry conditions – and some may have no connection with groundwater at all. Some aquifers are dependent almost entirely on recharge (see Figure 1). Based on the SANBI Biodiveristy Series 22, the following to water systems is present on the proposed area:

- **Unchanneled valley bottom** – Valley bottom area with no clearly defined stream channel gently sloped and characterized by alluvial sediment deposition. Water inputs mainly from channel entering the wetland and also from adjacent slopes
- **Channelled valley bottom** – The valley bottom had a well-defined stream channel but lacked characteristic floodplain features. It is gently sloped and characterized by the net accumulation of alluvial deposits. Water inputs is expected from the main channel (when channel banks overspill) and from adjacent slopes.

The channelled valley bottom wetland system found on site is fed by a larger unchanneled valley bottom wetland system. This system is from a much larger catchment on the to the south of the proposed OC4 mining area. For the impact assessment the two wetland systems have been grouped together.

6.2 Assumptions

Wetlands are dependent on rainfall infiltrating the upslope soil, being partitioned by the subsoil and fractured rock, before flowing down slope to return to the soil surface and wetland, sometimes via a river system. A wetland may thus be considered a signature of the hydrological dynamics of its surrounding catchment. Wetlands are dependent on rainfall infiltrating the upslope soil, being partitioned by the subsoil and fractured rock, before flowing down slope to return to the soil surface and wetland, sometimes via a river system. A wetland may thus be considered a signature of the hydrological dynamics of its surrounding catchment.

The wetland's catchment determines the relative extent of different hydrological response types in the catchment and within specific hillslopes contained within the catchment. The impact on flow drivers of the wetland catchment is detailed below and is based on the following assumptions (*status quo*). A water balance[2] on the wetland catchment is represented by:

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[2] Dynamics of MODIS evapotranspiration in South Africa, Nebo Jovanovic1*, Qiaozhen Mu2, Richard DH Bugan1 and Maosheng Zhao3, 1CSIR, Natural Resources and Environment. ISSN 0378-4738 = Water SA Vol. 41 No. 1 January 2015

- Rainfall 100% of flow input
- Evapotranspiration is 50 – 70% of rainfall (outflow)
- Runoff is 10% (outflow)[3]
- Groundwater recharge is 5%[4] (outflow)
- 20 -30 % of the water being left in or stored the unsaturated zone or interflow zone feeding the wetland

The impact assessment is only valid for OC4 and OC4A, based on the site visit historic activity and agricultural activities has impacted on the wetland systems. Current flow driver impacts from existing and neighbouring mines/agricultural activities was not part of the impact assessment.

6.3 Flow drivers

The following episodic flow drivers are relevant to the wetland system:

- Groundwater recharge = 569500 m^3/a
- Direct rainfall on wetland soils = 300160 m^3/a
- Run off = 797300 m^3/a

Water stored in the interflow or responsive soils:

- 300160 m^3/a

It is clear from the above that surface run off water, followed by direct rainfall and then water stored in the wetland soils are the main water components of the wetland system south of the Olifants river (see **Figure 9**). In contrast the largest impact on the wetland system is the disruption of water stored in the interflow and responsive wetland soils as shown in **Table 3** and Figure 10.

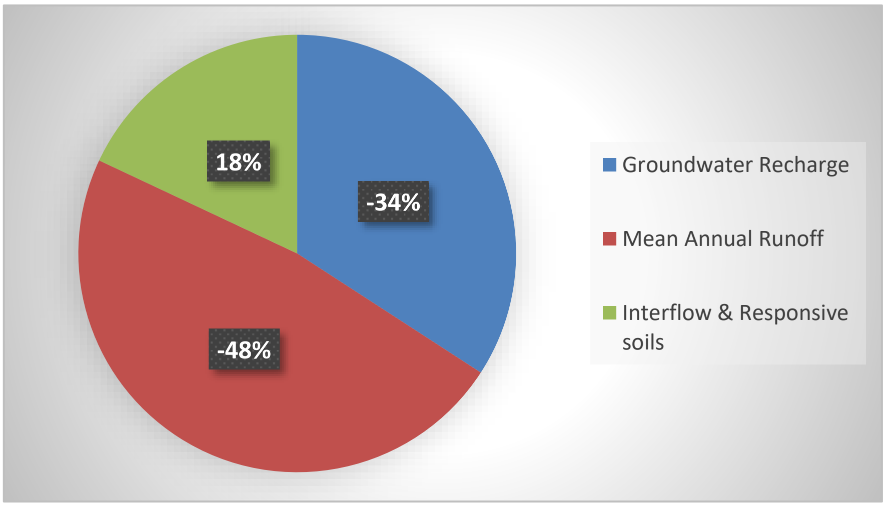

Figure 9: Contribution in terms of flow driver percentages (pre mining)

[3] Midgley, D.C., Pitman, W.V. & Middleton, B.J. (1994) Surface Water Resources of South Africa **1990**. Water Research Commission Report No 298/5.1/94, Pretoria, South Africa.
[4] An investigation into recharge in South African underground collieries by P.D. Vermeulen* and B.H. Usher. The Journal of The Southern African Institute of Mining and Metallurgy- Volume 106 -

6.4 OC4 and OC4A

The impact percentages in terms of flow drivers are detailed in Figure 10 and Table 3 below. The largest impact is on the wetland soil storage potential, followed by run-off and then groundwater.

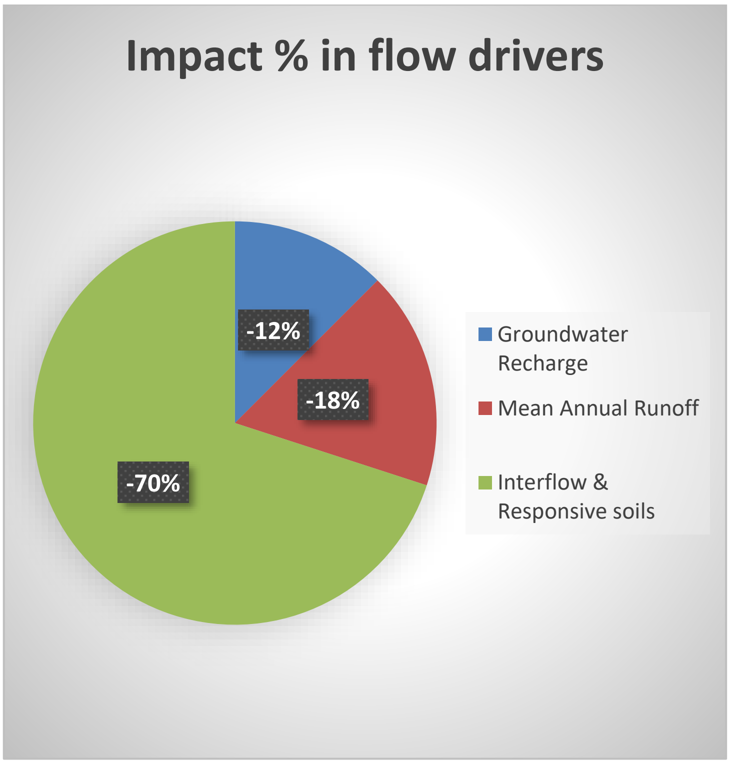

Figure 10: Contribution in terms of flow driver impact percentages (during mining OC4 & OC4A)

6.5 TSF

The tailings storage scenario could result in two scenarios depending on if the facility will be lined or left unlined:

- If **unlined** there could be a positive flow impact as a result of increased porosity of the tailings material as well as increased run-off due to increased slopes. It should however be noted that this increased recharge/run-off could be contaminated having a negative quality impact on downgradient surface water resources.

Table 2: Area information

Area information			Description	Source of information
Water balance input	m/annum	%	Inflow/Outflow	
Rainfall	0.67	100.0%	Inflows	VANDYKSDRIFT Weather Station (0478546_W)
Evapotranspiration	-0.40	-60.0%	Outflows	Dynamics of MODIS evapotranspiration in South Africa
Groundwater Recharge	-0.03	-5.0%	Outflows	An investigation into recharge in South African underground collieries by P.D. Vermeulen* and B.H. Usher. The Journal of The Southern African Institute of Mining and Metallurgy- Volume 106 -
Mean Annual Runoff	-0.05	-7.0%	Outflows	Calculated using Utility Programs for Drainage 1.0.1
Water in wetland soils	0.19	28.0%	Stored in responsive soil	Calculated

Table 3: Wetland flow driver impact losses (OC4 & OC4A)

Description	Volume pre development (m3/a)	Volume during mining (m3/a)	Volume loss (m3/a)	% Loss
Groundwater Recharge	-569500	-567268.9670	-2231.03	1-3
Mean Annual Runoff	-797300	-794176.5538	-3123.45	1-2
Interflow & Responsive soils	300160	287666.2152	-12493.78	2 -5%

Table 4: Wetland flow driver impact losses (TSF)

Unlined				
Description	**Volume pre development (m3/a)**	**Volume during mining (m3/a)**	**Volume increase (m3/a)**	**% Gain**
Groundwater Recharge	569500	740350	170850	20-30%
Mean Annual Runoff	797300	956760	159460	10 to 20%
Interflow & Responsive soils	300160	300160	-12493.78	0%
Lined				
Description	**Volume pre development (m3/a)**	**Volume during mining (m3/a)**	**Volume loss(m3/a)**	**% Loss**
Groundwater Recharge	569500	541025	-28475	3-5%
Mean Annual Runoff	797300	717570	-79730	10 to 20%
Interflow & Responsive soils	300160	300160	0	0%

Please note that the impacts above are only related to the impact of OC4 on the wetland system and not on the Olifants river. Furthermore, the values should not be taken as empirical results but rather as indicators for potential impact as worst case.

7 IMPACT ASSESSMENT

The wetlands on site reflect the behaviour of water, predominantly rainfall, and its behaviour following interception and infiltration into the soils. Thus, activities that affect the movement of water as well as its quality in the catchment areas supporting wetlands, translate into changes in the pans to which they are invariably linked. Expected impacts include:

- Change in hydrology.
- Change in water quality, and
- Loss of wetlands and the biodiversity supported by these wetlands.

Impacts that lead to a change in hydrology include all impacts that influence the quantity (e.g., increased or decreased run-off) and velocity (e.g., concentration of flows) of flows leaving the site.

Increased flows and increased velocity of flows could result in increased erosion within the receiving environment, while decreased flows could result in a decreased wetland functionality.

Impacts that lead to deteriorating water quality, together with the impacts that change the hydrology, are expected to be the most significant impacts on site. From a wetland perspective, mitigation measures and management plans should focus on these impacts and it will need to be clearly shown in the EIA and EMP how these impacts will be ameliorated to prevent significant deterioration of the quality and quantity of water discharged to downstream areas. The impact assessment is discussed in the heading below.

The impact quantification was done using the procedures for the assessment and minimum criteria for reporting aquatic biodiversity in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998. In terms of groundwater the proposed development impact on the functioning of the aquatic feature in terms of:

- Baseflow.
- Quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem.
- Quality of water.
- The location of areas not suitable for development, which are to be avoided during construction and operation, where relevant.
- Additional environmental impacts expected from the proposed development
- The degree to which impacts, and risks can be mitigated.
- The degree to which the impacts and risks can be reversed.
- The degree to which the impacts and risks can cause loss of irreplaceable resources.
- A suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies.

Two impact scenarios were done:

- Scenario 1 – No diversion
- Scenario 2 – With a diversion

7.1 Environmental Impact Assessment (EIA) Regulations, 2017

The Environmental Impact Assessment (EIA) 2014 Regulations [as amended] promulgated in terms of Sections 24 (5), 24M and 44 of the National Environmental Management Act, 1998 (Act No. 107 of 1998) [as amended] (NEMA), requires that all identified potential impacts associated with the proposed project be assessed in terms of their overall potential significance on the natural, social and economic environments. The criteria identified in the EIA Regulations (2014) include the following:

7.1.1 Extent of the impact

The extent of the impact is the physical extent/area of impact or influence. The ratings for the extent of the impact are given in the table below:

Table 5: Extent of the impact

Extent of the impact		
The EXTENT of an impact is the physical extent/area of impact or influence.		
Score	Extent	Description
1	Footprint	The impacted area extends only as far as the actual footprint of the activity.
2	Site	The impact will affect the entire or substantial portion of the site/property.
3	Local	The impact could affect the area including neighbouring properties and transport routes.
4	Region	Impact could be widespread with regional implication.
5	National	Impact could have a widespread national level implication.

7.1.2 Duration of the impact

The duration of an impact is the expected period of time the impact will have an effect. The ratings for the duration of the impact are given in the table below:

Table 6: Duration of the impact

Duration of the impact		
The DURATION of an impact is the expected period of time the impact will have an effect.		
Score	Duration	Description
1	Short term	The impact is quickly reversible within a period of less than 2 years, or limited to the construction phase, or immediate upon the commencement of floods.
2	Short to medium term	The impact will have a short-term lifespan (2–5 years).
3	Medium term	The impact will have a medium-term lifespan (6 – 10 years)
4	Long term	The impact will have a medium-term lifespan (10 – 25 years)
5	Permanent	The impact will be permanent beyond the lifespan of the development

7.1.3 Probability of the impact occurring

The probability of an impact is the severity of the impact on the ecosystem structure. The ratings for the probability of the impact occurring are given in the table below:

Table 7: Probability of the impact occurring

Probability of the impact		
The PROBABILITY of an impact is the severity of the impact on the ecosystem structure		
Score	Probability	Description
1	Improbable	The possibility of the impact occurring is highly improbable (less than 5% of impact occurring).
2	Low	The possibility of the impact occurring is very low, due either to the circumstances, design or experience (5% to 30% of impact occurring).
3	Medium	There is a possibility that the impact will occur to the extent that provision must be made therefore (30% to 60% of impact occurring).
4	High	There is a high possibility that the impact will occur to the extent that provision must be made therefore (60% to 90% of impact occurring).
5	Definite	The impact will definitely take place regardless of any prevention plans, and there can only be relied on migratory actions or contingency plans to contain the effect (90% to 100% of impact occurring).

7.1.4 Degree to which impact can be reversed

The reversibility of an impact is the severity of the impact on the ecosystem structure. The ratings for the degree to which the impact can be reversed are given in the table below:

Table 8: Degree to which impact can be reserved

Score	Reversibility	Description
1	Completely reversible	The impact is reversible without any mitigation measures and management measures
2	Nearly completely reversible	The impact is reversible without any significant mitigation and management measures. Some time and resources required.
3	Partly reversible	The impact is only reversible with the implantation of mitigation and management measures. Substantial time and resources required.
4	Nearly irreversible	The impact is can only marginally be reversed with the implantation of significant mitigation and management measures. Significant time and resources required to ensure impact is on a controllable level.
5	Irreversible	The impact is irreversible.

7.1.5 Intensity of the impact

The intensity of an impact is the expected amplitude of the impact. The ratings for the degree of the intensity of the impact are given in the table below:

Table 9: Intensity of the impact

Score	Intensity	Description
1	Minor	The activity will only have a minor impact on the affected environment in such a way that the natural processes or functions are not affected.
2	Low	The activity will have a low impact on the affected environment.
3	Medium	The activity will have a medium impact on the affected environment, but function and process continue, albeit in a modified way.
4	High	The activity will have a high impact on the affected environment which may be disturbed to the extent where it temporarily or permanently ceases.
5	Very High	The activity will have a very high impact on the affected environment which may be disturbed to the extent where it temporarily or permanently ceases.

7.1.6 Cumulative impacts.

The impact assessment methodology (as defined below) whereby the Significance of a potential impact is determined through the assessment of the relevant temporal and spatial scales determined of the Extent, Magnitude and Duration criteria associated with a particular impact. This method does not explicitly define each of the criteria but rather combines them and results in an indication of the overall significance.

The cumulative pollution impacts of all current and historical activity at the mine is considered insignificant as the residence time of stockpiles prior to loading and transport is short and impact duration is considered short-term.

Table 10: Significance Rating of Impact(s)- wetland flow (quantity) only not Olifants river impacts.

Impacts	Extent	Duration	Intensity	Reversibility	Probability	Significance = Irreplaceability (Reversibility + Intensity + Duration + Extent) X Probability		Mitigation Efficiency (ME)	Significance Rating (WM) = Significance Rating (WOM) x Mitigation Efficiency	
No diversion	1	3	3	3	4	40	Medium	1	40	Medium
With diversion	1	3	3	3	4	40	Medium	0.8	32	Low
TSF no lining	1	3	3	3	4	40	Medium	0.8	32	Low
TSF with lining	1	3	3	3	4	40	Medium	0.8	32	Low

Table 11: Risk rating description

Score	Significance	Colour Code
1 to 20	Very low impact	
21 to 40	Low impact	
41 to 60	Medium impact	
61 to 80	High impact	
81 to 100	Very high impact	

8 MITIGATION MEASURES

The following mitigation measures are proposed:

- Mitigation measures recommended in the Aquatic ecosystem mitigation plan for the Seam 2 Mine North block 2 done by Galago Environmental in November 2020 should be done. In summary these mitigation measures are:
    - Installation of a berm to prevent ingress of the Olifants River into the mining area. ***Based on the site visit of October 2022 this berm is already in place.***
    - Stripping of topsoil from the wetland,
    - Removal and storage of hydrophytes,
    - Stockpiling of the stripped topsoil,
    - Diversion of the wetland flows from the catchment to the Olifants River system, ***based on the site visit of October 2022 this berm is already in place.***
    - Emulating wetland functionality brought by the interaction of the riparian area on the wetland. The largest expected function is the attenuation of the river especially during flooding events,
    - Reshaping of the mined area post mining,
    - Reinstatement of the wetland functionality into the mined area
- Confine any unpolluted water to a clean water system, away from any dirty area through upstream diversions as follows:
    - Groundwater -2200 to 2300 m^3/a, through installing shallow boreholes (50 m) and abstracting clean water. This groundwater should then be released into the diversion through seasonal disperse flow, as designed by the wetland rehabilitation specialist.
    - Surface water 3100 to 3200 m^3/a, through a system of clean water cut-off trenches and diversion berms
    - Interflow 1300 to 1400 m^3/a. In contrast to the above the diversion should allow rehabilitation/reinstatement of disturbed wetland soils to be replaced at the diversion section. A total area of 66598 m^2 of responsive wetland soils will be required to simulate the losses from OC4. The replacement of these soils should be overseen by a wetland rehabilitation specialist. The thickness of the soils should be determined by the wetland rehabilitation specialist.
- Collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity into a dirty water system; and
- Design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years.
- Please note that the above mitigation measures are only applicable to the impacts on the wetland system and not impacts on the Olifants river.

9 CONCLUSIONS

OC4 could impact on the flow drivers of the wetland systems through interception systems such as dewatering, diversions, drainage systems and water quality changes, for this a berm and wetland diversion is already in place. As OC4A is situated on recharge no wetland impacts (not river impacts) are foreseen except for some decrease in direct rainfall on the footprint area.

Depending on the design of the proposed TSF it could have negative (lined facility) or positive flow (unlined) facility on the wetland catchment. It should however be noted that in the unlined facility scenario although positive flow (quantity) could be expected the flow could mobilise contaminants which has the potential to negatively impact the catchment from a quality side.

Mining is at the low point of the wetland and only intersects a small portion of the wetland with lower impacts than expected was obtained during the impact assessment. However, as the wetland system directly feeds into the Olifants river the impacts if not mitigated is expected on the river and therefore should mining be conducted should only be done with a diversion or similar offset strategy. As the planned OC4A is on recharge soils the impacts from dewatering of groundwater (lowering of the groundwater level) could lead to a decrease in baseflow to the Olifants River which is beyond the scope of hydropedology.

9.1 Main mitigation measures

The following mitigation measures are proposed:

- Mitigation measures recommended in the Aquatic ecosystem mitigation plan for the Seam 2 Mine North block 2 done by Galago Environmental in November 2020 should be done. In summary these mitigation measures are:
    - Installation of a berm to prevent ingress of the Olifants River into the mining area. ***Based on the site visit of October 2022 this berm is already in place.***
    - Stripping of topsoil from the wetland,
    - Removal and storage of hydrophytes,
    - Stockpiling of the stripped topsoil,
    - Diversion of the wetland flows from the catchment to the Olifants River system, ***based on the site visit of October 2022 this berm is already in place.***
    - Emulating wetland functionality brought by the interaction of the riparian area on the wetland. The largest expected function is the attenuation of the river especially during flooding events,
    - Reshaping of the mined area post mining,
    - Reinstatement of the wetland functionality into the mined area
- Confine any unpolluted water to a clean water system, away from any dirty area through upstream diversions as follows:
    - Groundwater -2200 to 2300 m^3/a, through installing shallow boreholes (50 m) and abstracting clean water. This groundwater should then be released into the diversion through seasonal disperse flow, as designed by the wetland rehabilitation specialist.
    - Surface water 3100 to 3200 m^3/a, through a system of clean water cut-off trenches and diversion berms
    - Interflow 1300 to 1400 m^3/a. In contrast to the above the diversion should allow rehabilitation/reinstatement of disturbed wetland soils to be replaced at the diversion section. A total area of 66598 m^2 of responsive wetland soils will be required to simulate the losses from OC4. The replacement of these soils should be overseen

by a wetland rehabilitation specialist. The thickness of the soils should be determined by the wetland rehabilitation specialist.

- Collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity into a dirty water system; and
- Design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years.
- Please note that the above mitigation measures are only applicable to the impacts on the wetland system and not impacts on the Olifants river.

9.2 Recommendation

The following recommendations are put forward:

- The water flow and quality in the wetland system should be measured on a quarterly basis for the following variables:
  - Flow (m^3/day)
  - pH (pH units)
  - TDS (mg/l)
  - SO4 (mg/l)
  - Full metals by ICP-OES (mg/l)
  - The monitoring points should be where the unchanneled valley bottom feeds water to the channelled valley bottom as well as where the wetland enters the Olifants River.
- All diversions (wetland and river) should be overseen by a wetland rehabilitation specialist and engineer to prevent negative impacts on the riparian zone of the Olifants river.