APPENDIX T: HYDROPEDOLOGY

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Hydropedological Assessment for the Proposed Melmoth Iron Ore Mine

Report

Version - Final 2

12 December 2022

SLR

GCS Project Number: 22-0906

Client Reference: EP561-SC01

HYDROPEDOLOGICAL ASSESSMENT FOR THE PROPOSED MELMOTH IRON ORE MINE

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DECLARATION OF INDEPENDENCE

GCS (Pty) Ltd was appointed to conduct this specialist study and to act as the independent hydropedological specialist. GCS objectively performed the work, even if this results in views and findings that are not favourable. GCS has the expertise in conducting the specialist investigation and does not have a conflict of interest in the undertaking of this study. This report presents the findings of the investigations which include the activities set out in the scope of work.

EXECUTIVE SUMMARY

GCS Water and Environment (Pty) Ltd (GCS) was appointed by SLR to undertake a hydropedological assessment for the proposed Jindal Iron Ore project situated near Melmoth, in the KwaZulu-Natal Province. The project is spread over three (3) quaternary catchments (namely W12B, W12C and W12D) of the Pongola to Mtamvuna Water Management Area (WMA) (DWS, 2016).

Table 1 below provides a cross-reference summary of report sections, as per the requirements of Appendix 6 of GN 326 EIA Regulation 2017.

Table 1 - Requirements from Appendix 6 of GN 326 EIA Regulation 2017

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	Chapter
(a) Details of: (i) The specialist who prepare the reports; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Page ii Appendix F.
(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority	Appendix F.
(c) Indication of the scope of, and purpose for which, the report was prepared	Section 1.
(cA) Indication of the quality and age of base data used for the specialist report	Sections 1, 2 and 6.
(cB) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 4.
(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment	Section 1.
(e) Description of the methodology adopted in preparing the report or carrying out the specialised process include of equipment and modelling used	Section 1.
(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associate's structures and infrastructure, inclusive of a site plan identifying alternatives	Sections 4 and 5.
(g) Identification of any areas to be avoided, including buffers	Sections 4 and 5.
(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers	Sections 4 and 5.
(i) Description of any assumptions made and uncertainties or gaps in knowledge	Section 1.4, 1.7 and 4.2.1.
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity including identified alternatives on the environment or activities	Sections 4 and 5.
(k) Mitigation measures for inclusion in the EMPr	Sections 4 and 5.
(l) Conditions for inclusion in the environmental authorisation	Refer to recommendations in Section 5.1.

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	Chapter
(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation	Refer to the recommendations in Section 5.1 and the impact table in Section 4.4.
(n) Reasoned opinion – (i) as to whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, and avoidance, management, and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 6.
(o) Description of any consultation process that was undertaken during preparing the specialist report	*None required.*
(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto	*None required.*
(q) Any other information requested by the competent authority	*TBC.*

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STANDARD LIST OF ACRONYMS FOR HYDROPEDOLOGY

Acronym	Description
A	Diagnostic A horizon
A/B	Interflow soil type A/B
A/Bedrock	Interflow soil type A/Bedrock
B (B1, B2, B3 etc.)	Diagnostic B horizon
BA	Basic Assessment
BOD	Biological oxygen demand
COD	Chemical oxygen demand
CSWMP	A conceptual stormwater management plan
CVB	Channelled valley bottom wetland
DEM	Digital Elevation Model
DWS	Department of Water and Sanitation
E	Diagnostic E horizon
EIS	Ecological importance and Sensitivity
G	G Horizon/soil
GCS	GCS Water and Environment (Pty) Ltd.
GN704	General Notice 704
ha	Hectare
HOSASH	Hydrology of South African Soils and Hillslopes
HRU	Hydrological Response Unit
HST	Hydrological Soil Type
IWULA	Integrated Water Use Licence Application
m^3	Cubic Metres
MAE	Mean annual evaporation
MAR	Mean Annual Runoff
MIPI	Midgley and Pitman (runoff calculation method)
Ml	megalitre
NEMA	National Environmental Management Agency
NFEPA	National Freshwater Environmental Protected Areas
n-Value	Manning's Roughness Coefficients
NWA	National Water Act, 1998 (Act No. 36 of 1998)
O	Orthic Horizon/soil
PCD	Pollution Control Dam
PES	Present Ecological State
PFD	Process flow diagram
RP	Riparian zone / wetland
S	Seepage wetland
SDF	Standard design flood
SW	Surface Water
TDS	Total dissolved solids
TIN	Triangulated Irregular Network
UCVB	Unchanneled valley bottom wetland
UVB	un-channelled valley bottom
V	Vertic Horizon/soil
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012
WTW	Water Treatment Works

1 INTRODUCTION

GCS Water and Environment (Pty) Ltd (GCS) was appointed by SLR to undertake a hydropedological assessment for the proposed Jindal Iron Ore project situated near Melmoth, in the KwaZulu-Natal Province (refer to Figure 1-1). The project is spread over three (3) quaternary catchments (namely W12B, W12C and W12D) of the Pongola to Mtamvuna Water Management Area (WMA) (DWS, 2016).

1.1 Project background

Jindal Iron Ore (Pty) Ltd. (Jindal), the South African operating subsidiary of multinational Indian conglomerate Jindal Steel and Power Limited (JSPL) holds two prospecting rights for two (2) areas of land, the North Block and the South Block, 25 km south-east of Melmoth in KZN, South Africa (refer to Figure 1-1). The North Block, PR 10644, is 8.467 ha and the South Block, PR 10652, is 11.703 ha.

Jindal appointed Amec (Pty) Ltd. to conduct a Prefeasibility Engineering Study to determine the technical and financial feasibility of establishing an iron ore mining operation on site. Jindal now wishes to submit a mining right application before the expiration of the prospecting rights.

The production will ramp up to 20 mtpa in the first phase. The project requires an integrated Environmental Authorisation under; the National Environmental Management Act (NEMA) (Act 107 of 1998), the National Environmental Management: Waste Act (NEMWA) (Act 59 of 2008), and a Water Use Licence (WUL) under the National Water Act (NWA) (Act 36 of 1998). In addition, a Social and Labour Plan and a Mine Works Programme will be generated as part of this project.

The project area is predominantly rural with primary land uses including forestry plantations, grasslands, commercial agriculture (such as timber and sugar cane), small-scale agriculture, traditional subsistence agriculture, thickets and bush, and settlement areas. A large amount of the project area falls within the Zulu-Entembeni Traditional Authority Area which is managed by the Ingonyama Trust Board. It should be noted that the previous application will have sensitised communities in this area to the presence of the mine.

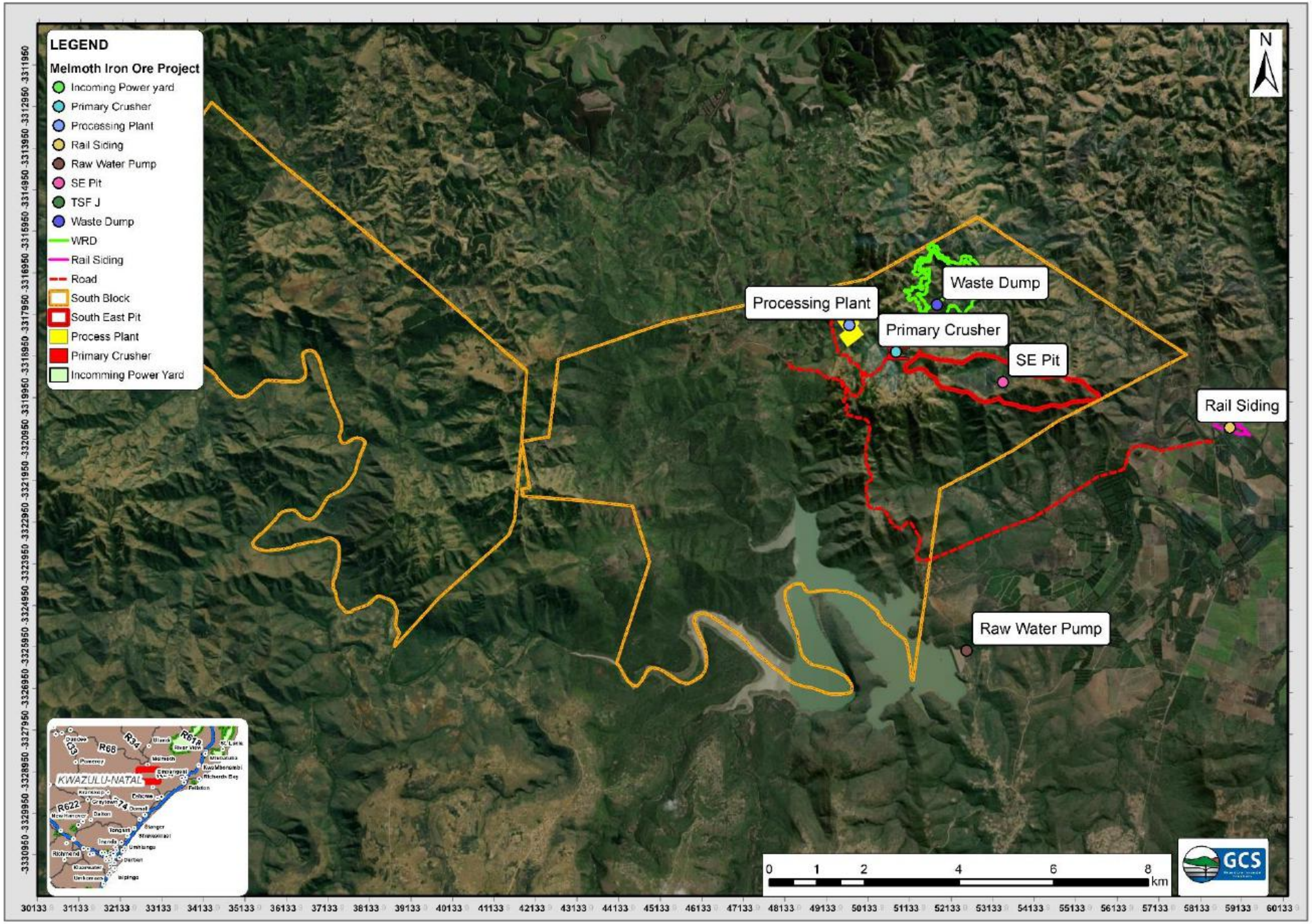


Figure 1-1: Site Layout and Conceptual Mining Areas

1.2 Study approach and methodology

Soils develop over time under the influence of chemical, physical, and biological processes (refer to Figure 1-2). Soils are predominantly the result of in-situ weathering of the host rock (i.e. has characteristics associated with the parent geological occurrence/rock). Soil has an interactive relationship with hydrology (i.e. climate, rainfall duration, runoff patterns, groundwater contribution to baseflow, evaporation etc.). It is a product of water-related processes (physical and chemical) and a first-order control of the destination of rainwater. Though hydrological processes change seasonally, soil characteristics and water transfer capabilities tend to change very slowly (i.e. may only be subjected to quick changes due to anthropogenic processes or advanced climate change patterns). *The study is not seasonally bound and is a once-off evaluation of the study area (i.e. there is no need to re-assess the study area in the winter or summer months, as soil flow conditions will highly likely remain the same).*

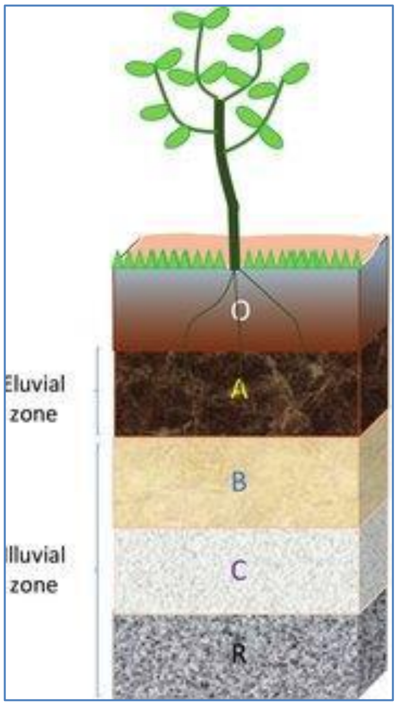


Figure 1-2: Typical soil genesis

The following general approach was followed:

1. Evaluate the soils in the study area:
   - Soils were classified per the taxonomic system for South Africa (Department of Agricultural Development, 1991) and natural and anthropogenic systems for South Africa - Soil Classification Working Group (SCWG, 2018) guidelines.
   - Soil permeability was estimated based on available data (i.e. public soil data) and according to best practice guidelines (FAO, 1980); and (DWS, 2011).
2. Derive hydropedological flow regimes and interaction areas:
   - In the determination of Hydrological Soil Types (HST), soils were divided into classes based on their expected hydrological responses (Van Tol, et al., 2013).
3. Conceptualise the water flow dynamics identified in the area:
   - Hydrological processes were perceived from traceable signatures in the soil matrix resulting from the soil's ability to transmit, store and react with water (Le Roux, et al., 2011).
4. Quantification of the hydropedological fluxes using a spreadsheet-based water balance model:
   - A simple spreadsheet-based water balance model was used to illustrate unsaturated zone fluxes/water balances.

5. Identify potential hydropedological impacts per standard DWS & EIA impact criteria and risk rating (refer to **Appendix A**).
6. Evaluate the potential impact on watercourses downstream of the site and subject to the proposed activities.

1.3 Legislative considerations

The study scope of works and objectives coincide with DWS guidelines for Hydropedology Studies (Van Tol; Bouwer, J.J, 2021) - Refer to **Appendix E**.

1.4 Study relevance to the season in which it was undertaken

This study was undertaken as a once-off study and relies on historical hydrological and climate data for the site; as well as recognized geological and water resource databases for South Africa. Data generated during the time of this study is not seasonally bound, even though low and high flow yield estimates were evaluated, as average yearly data was applied where required and as scientifically acceptable.

1.5 Objectives

The main objective of this study is to:

- Evaluate hillslope soils and determine hydrological soil types;
- Evaluate the hydropedological regime and determine the dominant soil flow drivers associated with the site;
- Estimate the likely impact on the hydropedological flow regime as a result of the proposed mining activity and associated infrastructure; and
- Comply with DWS requirements for WULAs/EIAs.

1.6 Scope of work

The scope of work completed was as follows:

1. **Desktop study:**
    a. Evaluation of soils in the study area, on a desktop level, based on available Land Types of South Africa (ARC, 2006) data was completed.
    b. Available public hydrological and wetland data was assessed. Moreover, specialist reports relating to the site (wetland and geohydrology reports) were also assessed.
2. **Field investigation:**

   a. A soil survey was undertaken of the project area, targeting hillslope, crest, and foot slope topographical areas – identified hillslopes from desktop evaluation.
   b. Auger boreholes were drilled to the confining layer of the material or as per the maximum depth of the auger equipment.
   c. The soils identified in the study area were classified according to Soil Classification guidelines (SCWG, 2018); and (Department of Agricultural Development, 1991), and a soil distribution map was generated.

3. **Hydropedological assessment:**
   a. Meteorological evaluation;
   b. Catchment delineation;
   c. Soil classification and characterisation; and
   d. HOSASH (Hydrology of South African Soils and Hillslopes) index.
4. **Data assessment:**
   a. All data obtained for the area was assessed in terms of suitable practices and screening protocols.
5. **Water balance and flow modelling:**
   a. A simple spreadsheet-based water balance model was used to illustrate unsaturated zone fluxes/water balances.
   b. The total water loss during a mining phase concerning the natural water processes in a sub-catchment was estimated. This was used in conjunction with the water balance flow model to determine the natural stream loss % for a sub-catchment and associated hillslopes.
6. **Risk assessment:**
   a. The risk and impact criteria (Refer to **Appendix A**) were applied to the study area, to evaluate hydropedological risks.
   b. Natural flow losses were estimated using a water balance, spreadsheet analytical model approach.
   c. The impact of dewatering on the local wetlands was evaluated by incorporating the Cooper-Jacob equation for constant drawdown and borehole interference.
7. **Mapping and report:**
   a. Several hydrological hillslope profiles, soil distribution and hydrological soil type maps were produced.

b. This report was compiled.

1.7 Study limitations

The following study limitations are recognised:

- The concepts presented are simplifications of the temporal variability of water transfer functions. Realistically, water transfer functions, such as throughflow and groundwater sources, may take a few months to several years to recharge streams (Le Roux, et al., 2011). However, hydropedology hillslopes have been effectively applied to simulate runoff response mechanisms (Van Tol, et al., 2013).
- Per minimum requirements for hydropedology studies published by DWS (Van Tol, J.J., Bouwer, D. & Le Roux, P.A.L., 2021), this "Step 3" study was undertaken (field investigation, conceptualisation of hillslopes, soil flow suppression and soil water balance modelling). No numerical unsaturated flow modelling (Step 4) was undertaken due to the data requirements (piezometric measurements and a dedicated monitoring system are required).
- Due to the large project area, the study consists of both desktop and more detailed intrusive investigation components. As the project is still in the planning phase commitments were made by GCS to SLR Consulting (end-client) to concentrate on higher-risk areas; and areas where conceptual drawings are available. The GCS approach to the study, focus areas and limitations are summarised in Table 1-1 below.
- The primary focus of this investigation is on the proposed processing plant, incoming yard, primary crusher, SE pit, waste rock dump (WRD - overburden), 400 kv powerline, plant access road and overland piping (primarily situated towards the eastern portion of South Block).
- It is understood that the proposed layouts are conceptual and that the mine plan and associated infrastructure may change to smaller footprint areas within the conceptual polygons provided. As such an analytical spreadsheet model was developed to illustrate 1st order impacts associated with the total conceptual mining areas provided. A numerical model will be necessary for a follow-up investigation after detailed designs and mine plans are available.
- It is understood that all gaps and data limitations noted during this investigation will be committed to as future works. This report can therefore be considered a work-in-progress document, which can be updated as the project changes from planning to the mining phase.

Table 1-1: Study limitations, focus areas and GCS approach

Area	Activity	GCS Approach
South Block	Processing Plant	GCS proposed an in-depth soil hydropedology survey in these areas. Priority for assessment due to planned activities as part of phase 1 of the mine (see layout provided).
	Incoming Power yard	
	Primary Crusher	
	SE Pit	
	Waste Dump (overburden)	
	400 kv Powerline	GCS proposes to screen the remaining components briefly in the field. Linear developments (i.e. powerline, overland piping and access roads) generally will have a low risk in terms of probable impacts on hydropedology. The aim is to briefly screen these areas in the field and to supplement desktop data. The primary focus is on the components above (processing and active mining).
	Plant Access Road	
	Overland Piping	
	All other areas in South Block, mainly concentrated towards the eastern portion where the above will take place	
North Block	North Block mine area	Phase 1 is situated in the northeast of the south block sector. North block is a future mining area, and hence will be screened on the desktop level. No field assessments are to be undertaken at this stage.
Outside South & North Block boundaries	400kv Powerline	The Roads, powerlines, tailing storage facility and railway sidings outside the south block boundary will not be assessed as part of this appointment. Only a short segment of the raw water pipeline to the raw water pump below the dam will be assessed (focused on Phase 1).
	Plant Access Road	
	Overland Piping	
	Railway Siding	
	Raw Water Pump	
	Tailings Storage Facility (**Part of a separate application**)	

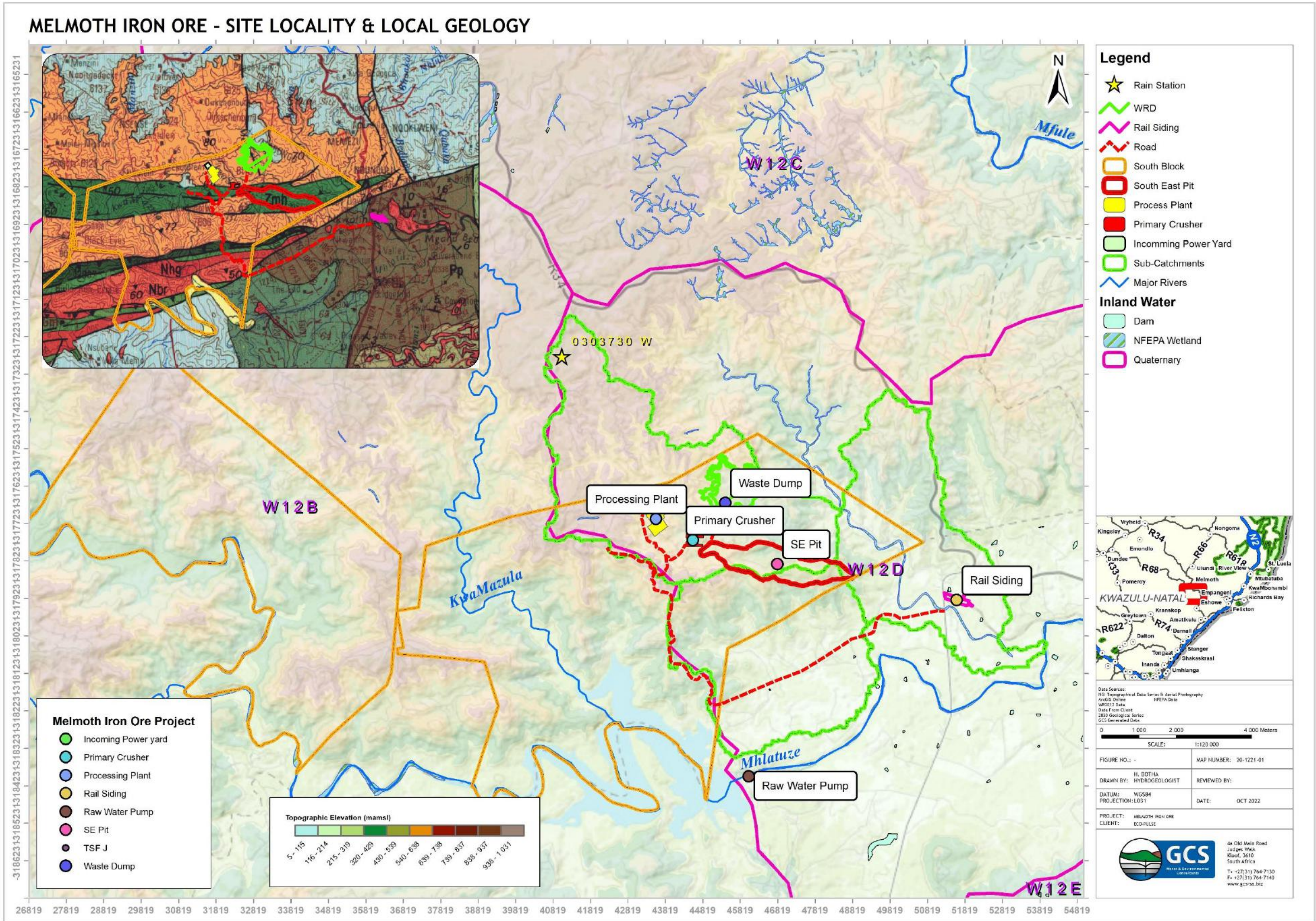


Figure 1-3: Site locality and local geology

2 SITE OVERVIEW

The following section supplies a brief overview of the regional setting, topography, climate, and geological and soil occurrences in the project area. The information in this section was obtained from the public domain and reports for the project.

2.1 Sub-catchments / hydraulic response unit (HRU)

As mentioned previously, the project is spread over three (3) quaternary catchments (namely W12B, W12C and W12D) of the Pongola to Mtamvuna Water Management Area (WMA) (DWS, 2016) – refer to Figure 1-3. Elevations for the project area range from 110 metres above mean sea level (mamsl) to 1000 mamsl. The topography is characterised by rolling hills and steep hilltops.

Three (3) sub-catchment / hydrological response units (HRU) (1:10 000 stream count, 20 mDTM fill) were delineated for the project area, and are based on the conceptual layouts provided for this assessment (i.e. the Processing Plant, incoming Power yard, Primary Crusher, SE Pit, Waste Dump (overburden), 400 kv Powerline, Plant Access Road and Overland Piping – refer to Figure 1-3. Drainage is generally towards the south-east over the project area via several non-perennial and perennial streams.

With regards to major river systems occurring in the area, the Northern Block is drained by the Mfule River, the South-West Block is drained by the Mhlatuze River and the South-East Block is drained by the Nkwalinye and KwaMazula Rivers which are Tributaries of the Mhlatuze River. Available data suggest that non-perennial streams and drainage lines tend to be ephemeral.

2.2 Climate

Climate, amongst other factors, influences soil-water processes and peak flows. The most influential climatic parameter is rainfall. Rainfall intensity, duration, evaporative demand and runoff were considered in this study to indicate rainfall partitioning within the project area.

2.2.1 Temperature

The average yearly temperature (refer to Figure 2-1) for the area project area (Melmoth used as a reference site) ranges from 20 to 36°C (high) and 2 to 16°C (Low). The study area is situated in a sub-tropical climate area, as per the Köppen Climate Classification (Kottek, et al., 2006).

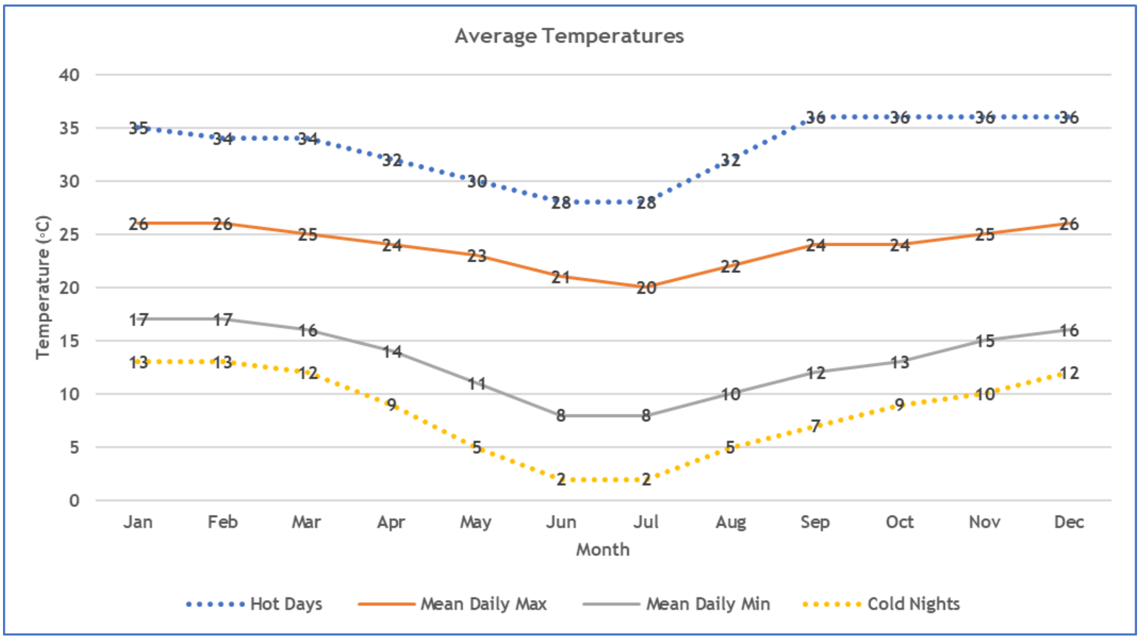


Figure 2-1: Average yearly temperatures (Meteoblue, 2021)

2.2.2 Wind speed and direction

Figure 2-2 shows the wind rose for the project area and presents the number of hours per year the wind blows from the indicated direction. Wind generally blows from N, S, SSE and NNE directions at higher velocities, when compared to wind coming from other directions.

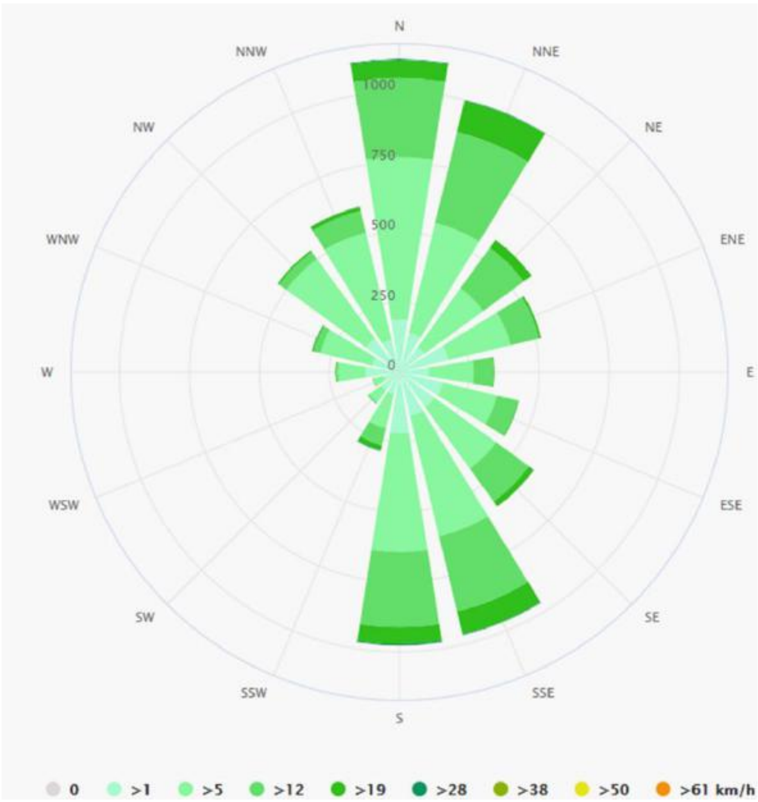


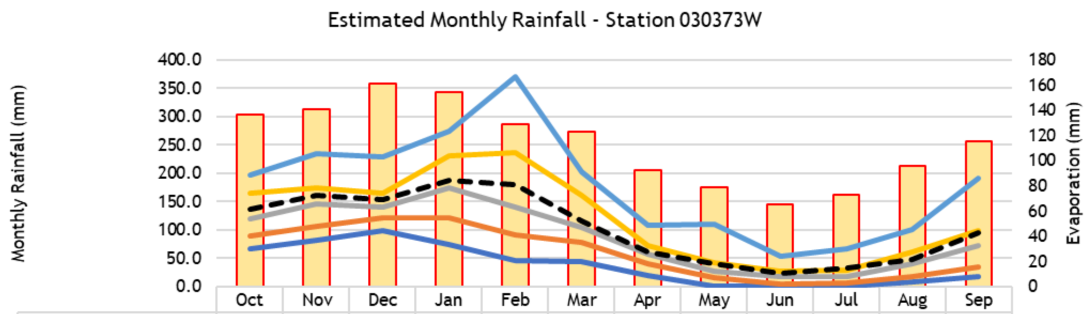
Figure 2-2: Wind rose (Meteoblue, 2021)

2.2.3 Rainfall and evaporation

The rainfall data used to calculate Mean Annual Precipitation (MAP) was obtained from rainfall station 030373, situated approximately 7km northwest (near Melmoth). Available rainfall data suggest a MAP ranging from 719 (30th percentile) to 1457 (70th percentile) mm/yr., based on a historical record of 31 years (i.e. 1971 to 2002).

Monthly rainfall for the site is likely to be distributed as shown in Figure 2-3, below. WR2012 data suggest a MAP for catchments W12C, W12B and W12D in the order of 848 mm/yr. (WRC, 2015).

The project falls within evaporation zone 22A, of which Mean Annual Evaporation (MAE) ranges from 1 300 to 1 350 mm/yr. The MAE far exceeds the MAP for the site, which implies greater evaporative losses when compared to incident rainfall. Monthly evapotranspiration for the site is likely to be distributed as shown in Figure 2-3, below.



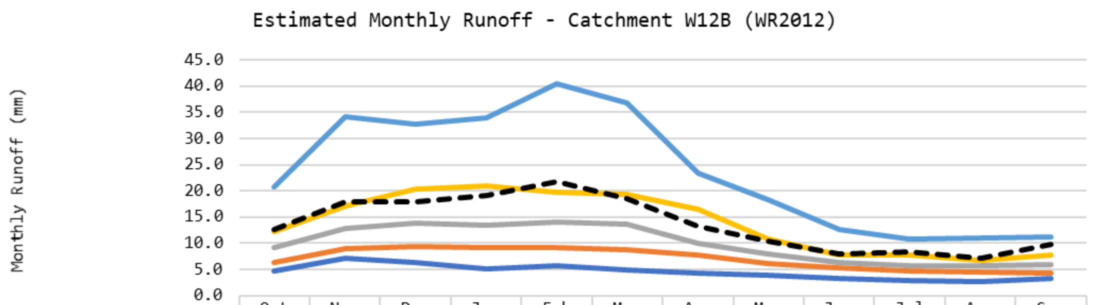
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evaporation	136	141	161	154	129	123	92	79	65	73	96	115
10th Percentile	67.1	81.5	99.2	74.2	45.5	43.6	18.2	0.0	0.0	0.2	8.0	16.3
30th Percentile	88.3	106.2	120.6	120.3	90.0	78.3	39.3	15.6	3.8	6.3	17.2	33.8
50th Percentile	119.0	146.1	140.5	173.5	140.5	104.0	57.6	26.5	17.5	16.5	39.0	71.7
70th Percentile	163.7	173.9	163.8	231.2	236.6	161.4	71.6	41.0	27.1	27.7	61.0	98.3
90th Percentile	195.6	234.3	227.8	273.4	369.3	201.5	107.5	109.9	52.9	66.8	100.3	190.7
Average	135.1	160.0	152.1	186.9	180.1	115.3	60.0	39.0	22.9	32.3	46.7	94.3

Month

Figure 2-3: Rainfall distribution and evaporation (station 030373W)

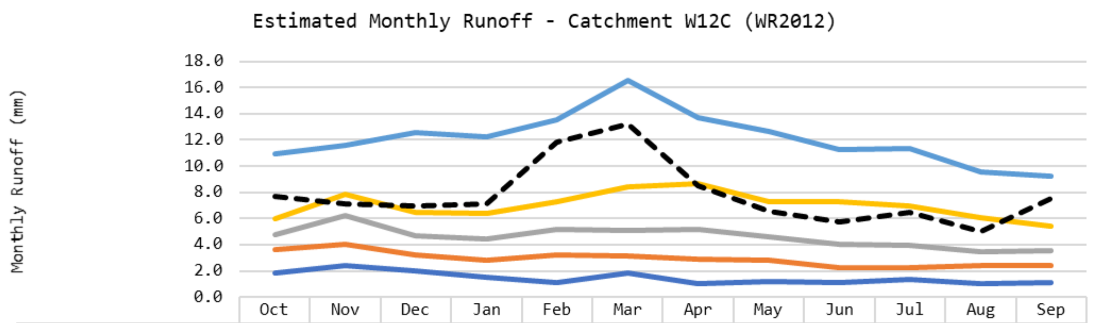
2.2.4 *Runoff*

Runoff from natural (unmodified) catchments in Catchments W12B, W12C and W12D are simulated in WR2012 as being equivalent to 41 to 66 mm/yr. over the surface areas of the sub-catchments (WRC, 2015). This is equal to approximately 3-5% of the MAP. Monthly runoff is distributed as shown in Figure 2-4 to Figure 2-6, below.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10th Percentile	4.7	7.2	6.4	5.1	5.8	4.9	4.3	3.9	3.3	2.8	2.7	3.3
30th Percentile	6.4	9.0	9.4	9.2	9.2	8.8	7.7	6.1	5.4	4.8	4.6	4.4
50th Percentile	9.1	12.9	13.8	13.5	14.0	13.6	10.1	8.0	6.3	5.8	5.7	5.9
70th Percentile	12.3	17.0	20.4	20.9	19.7	19.3	16.4	10.8	7.9	7.8	6.8	7.8
90th Percentile	20.7	34.2	32.8	34.1	40.4	36.9	23.5	18.3	12.7	10.9	11.0	11.1
Average	12.7	17.9	17.9	19.1	21.8	18.6	13.3	10.4	7.9	8.3	7.1	9.8

Figure 2-4: Simulated runoff for quaternary catchment W12B (WRC, 2015)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10th Percentile	1.8	2.4	2.0	1.5	1.1	1.8	1.0	1.2	1.1	1.3	1.1	1.1
30th Percentile	3.6	4.0	3.2	2.8	3.3	3.2	2.9	2.8	2.2	2.3	2.4	2.4
50th Percentile	4.7	6.3	4.7	4.4	5.2	5.1	5.1	4.6	4.1	3.9	3.5	3.6
70th Percentile	6.0	7.9	6.5	6.4	7.3	8.5	8.7	7.3	7.3	7.0	6.1	5.4
90th Percentile	10.9	11.6	12.5	12.2	13.5	16.5	13.7	12.6	11.3	11.3	9.6	9.2
Average	7.7	7.1	6.9	7.2	11.8	13.2	8.5	6.6	5.7	6.4	5.0	7.5

Figure 2-5: Simulated runoff for quaternary catchment W12C (WRC, 2015)

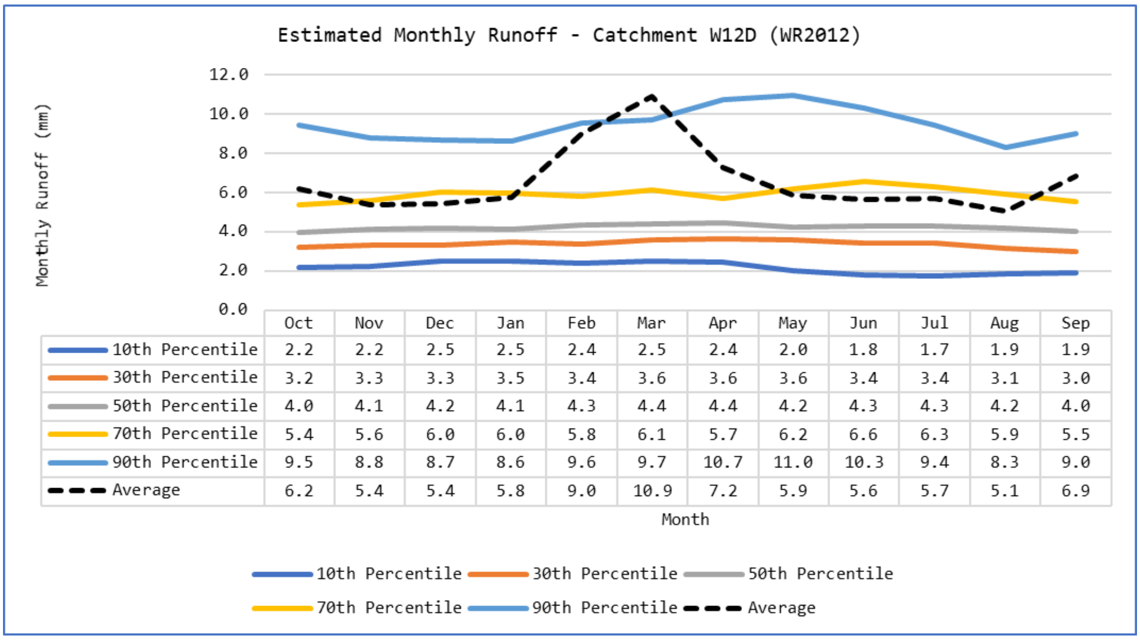


Figure 2-6: Simulated runoff for quaternary catchment W12D (WRC, 2015)

2.3 Depth to groundwater

Literature suggests an average groundwater level range from 25 to 35 (metres below ground level), for the greater quaternary catchments W12C, W12B and W12D (DWAF, 2006). However, based on available groundwater information project boreholes (GRIP) the water table is estimated to range from 15 to 64 mbgl - refer to Table 2-1.

There is a good Bayesian correlation (R ≈ 99%) between the topographic elevation (collar of the borehole) and the groundwater elevations, which suggests that the groundwater table mimics the topography (refer to Figure 2-7). No shallow groundwater ingress was observed in any of the auger test holes.

Table 2-1: GRIP boreholes within the immediate study area (within sub-catchments)

ID	Source	Latitude (WGS84) Decimal Degrees	Longitude (WGS84) Decimal Degrees	Elevation (mamsl)	Water Level (mbgl)
2831CB00052	GRIP	-28.705693	31.421421	694.377	No Data
2831CB00053	GRIP	-28.699303	31.425031	675.198	No Data
2831CB00055	GRIP	-28.724582	31.493092	424.674	37.57
2831CB00056	GRIP	-28.718472	31.465861	596.854	47.7
2831CB00057	GRIP	-28.738161	31.470892	229.514	No Data
2831CB00059	GRIP	-28.710892	31.416580	761.929	55.6
2831CB00060	GRIP	-28.707273	31.420050	698.326	64.5
2831CB00062	GRIP	-28.694464	31.472592	607.347	No Data
2831CB00066	GRIP	-28.692914	31.452581	659.743	23.64
2831CB00068	GRIP	-28.683464	31.435031	676.831	37.54
2831CBG0299	GRIP	-28.678470	31.442252	687.705	No Data
2831CBG1966	GRIP	-28.699302	31.425029	675.178	No Data
2831CBG1967	GRIP	-28.705690	31.421418	694.303	No Data
2831CBV0501	GRIP	-28.718470	31.465866	596.604	41.86
2831CBV0504	GRIP	-28.710889	31.416585	761.87	55.6
2831DA00110	GRIP	-28.746800	31.500864	165.21	15
2831DA00148	GRIP	-28.717222	31.531695	229.284	No Data

ID	Source	Latitude (WGS84) Decimal Degrees	Longitude (WGS84) Decimal Degrees	Elevation (mamsl)	Water Level (mbgl)
2831DA00149	GRIP	-28.717912	31.528925	232.362	No Data
2831DA00150	GRIP	-28.718472	31.530865	217.213	No Data
2831DA00172	GRIP	-28.714602	31.522113	241.844	No Data
2831DA00173	GRIP	-28.710583	31.520693	313.546	No Data
2831DAG2820	GRIP	-28.683470	31.517810	538.832	34
2831DAV0527	GRIP	-28.710257	31.520920	305.141	18.9
2831DAV0529	GRIP	-28.704670	31.519101	376.253	17.2

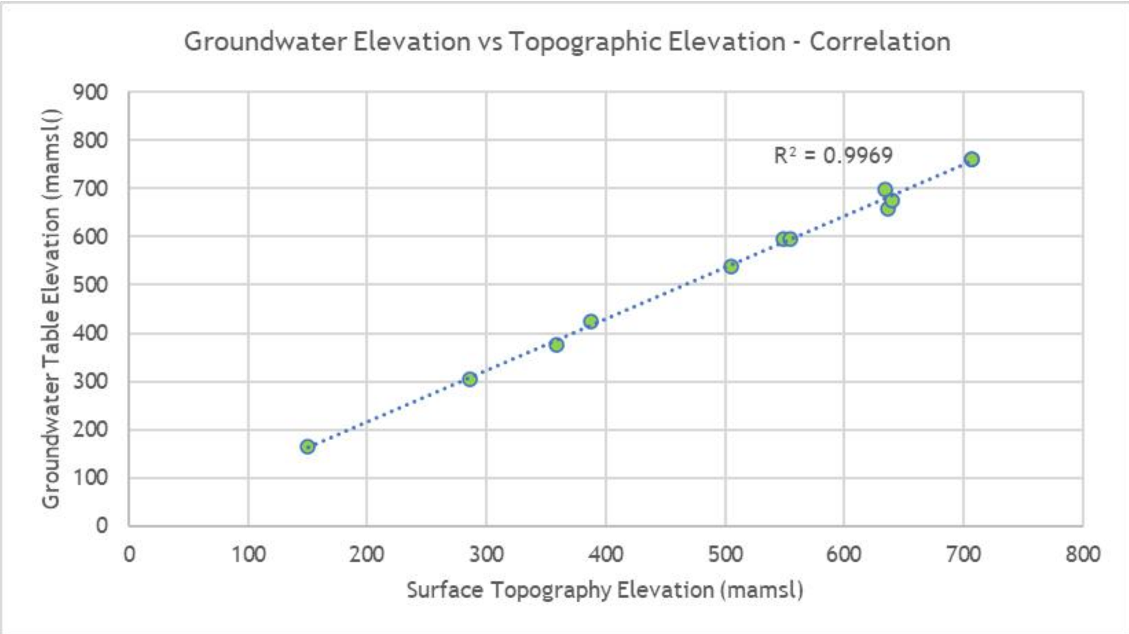


Figure 2-7: Topography vs Groundwater Elevation - Correlation

2.4 Wetland areas

Based on the National Freshwater Environmental Protected Areas (NFEPA) 2018 National Wetland Map 5 (Van Deventer, 2018) there are several wetland areas (concentrated along the Nkwalinye and KwaMazula Rivers which are Tributaries of the Mhlatuze River). Moreover, several wetland systems have been identified by Eco-Pulse, and are shown in Figure 2-9. The wetlands identified are primarily classified as unchanneled valley bottom wetlands (UCVB) and seepage bottom wetlands (Seeps).

In terms of wetland hydrology, both UCVB and Seep wetlands are maintained either permanently, seasonally, or temporarily via groundwater baseflow.

Baseflow (refer to Figure 2-8) is a non-process related term to signify low amplitude high-frequency flow in a river during dry or fair-weather periods. Baseflow is not a measure of the volume of groundwater discharged into a river or wetland, but it is recognised that groundwater contributes to the baseflow component of river or wetland flow.

Available literature (WRC, 2015; and DWAF, 2006) suggests groundwater contribution to baseflow ranging from 14 mm/yr (PITMAN MODEL) to 40 mm/yr (HUGHES MODEL). This relates to approximately 0.9 to 5.6% of rainfall.

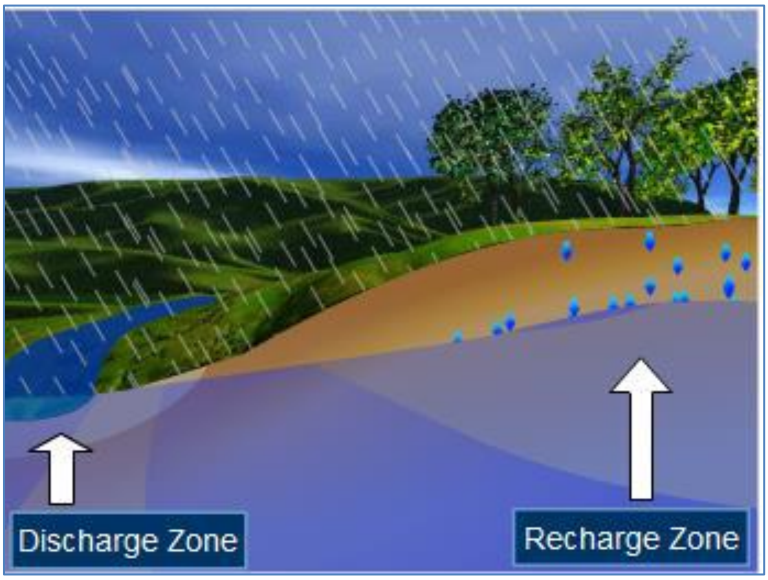


Figure 2-8: Groundwater baseflow concept (DWS, 2011)

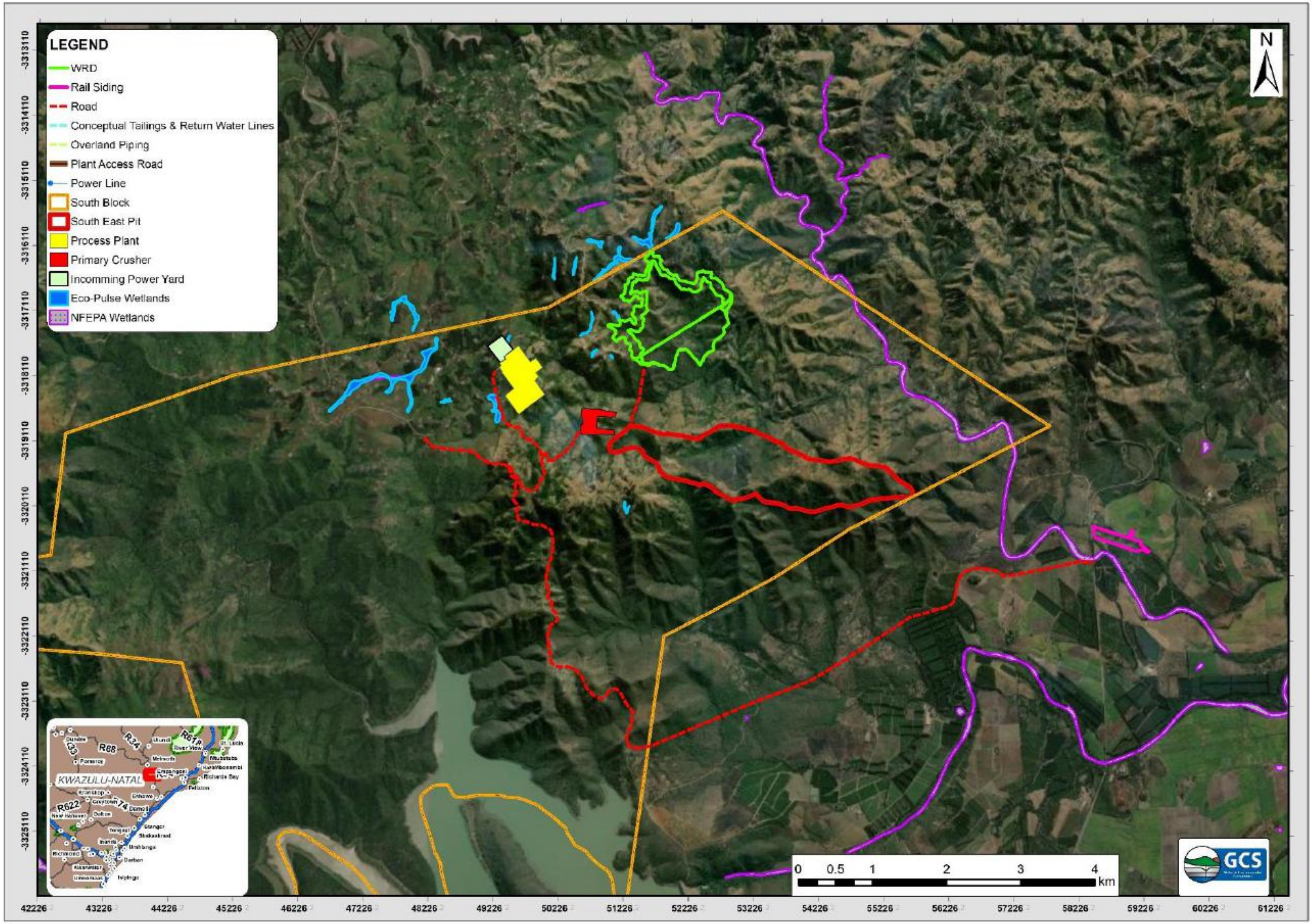


Figure 2-9: Wetland areas identified (NFEPA & Eco-Pulse)

2.5 Present ecological state (PES) and ecological importance and sensitivity (EIS)

The PES and EIS for the quaternary catchments are summarized as follows (SANBI, 2011); (DWS, 2018), (WRC, 2015):

- W12B: PES Desktop level = Class B: Largely Natural, EIS = High;
- W12C: PES Desktop level = Class A: Unmodified Natural, EIS = Moderate; and
- W12D: PES Desktop level = Class C: Moderately Modified, EIS = Moderate.

The above-mentioned were extracted from available desktop datasets. Refer to Eco-Pulse (2021) wetland report for PES and EIS determined in the field.

2.6 Local geology

According to the 2830 Dundee– 1:250 000 Geological map series (DMEA, 1998a) the surface geology for the project area is characterised by:

- North Block:
    - Predominantly Natal Group Sandstone as well as Swazium aged granitic gneiss.
- South Blocks:
    - Swazium aged basaltic lava, altered schist, iron formation, mica sheets and granitic-bearing grunerite schist (of the Mhlatuze Group), and granitic gneiss. It is the Mhlatuze Group iron-bearing formation that is targeted by the Melmoth Iron Ore project.

There is a north-striking fault zone associated with the conceptual WRD laydown area, as well as several lineaments between successions of granite and Natal group sandstone in the project area.

2.7 Soils and land morphology

Different soil types are encountered within shoulder, mid-slope and valley positions of the project area (referred to as soil hillslope) and are mainly due to sub-surface geology, products of weathering, degree of saturation, soil texture and slope position (refer to Figure 2-10).

The land types associated with the mining blocks, as well as the conceptual infrastructure layouts provided, are summarised in Table 2-2, below.

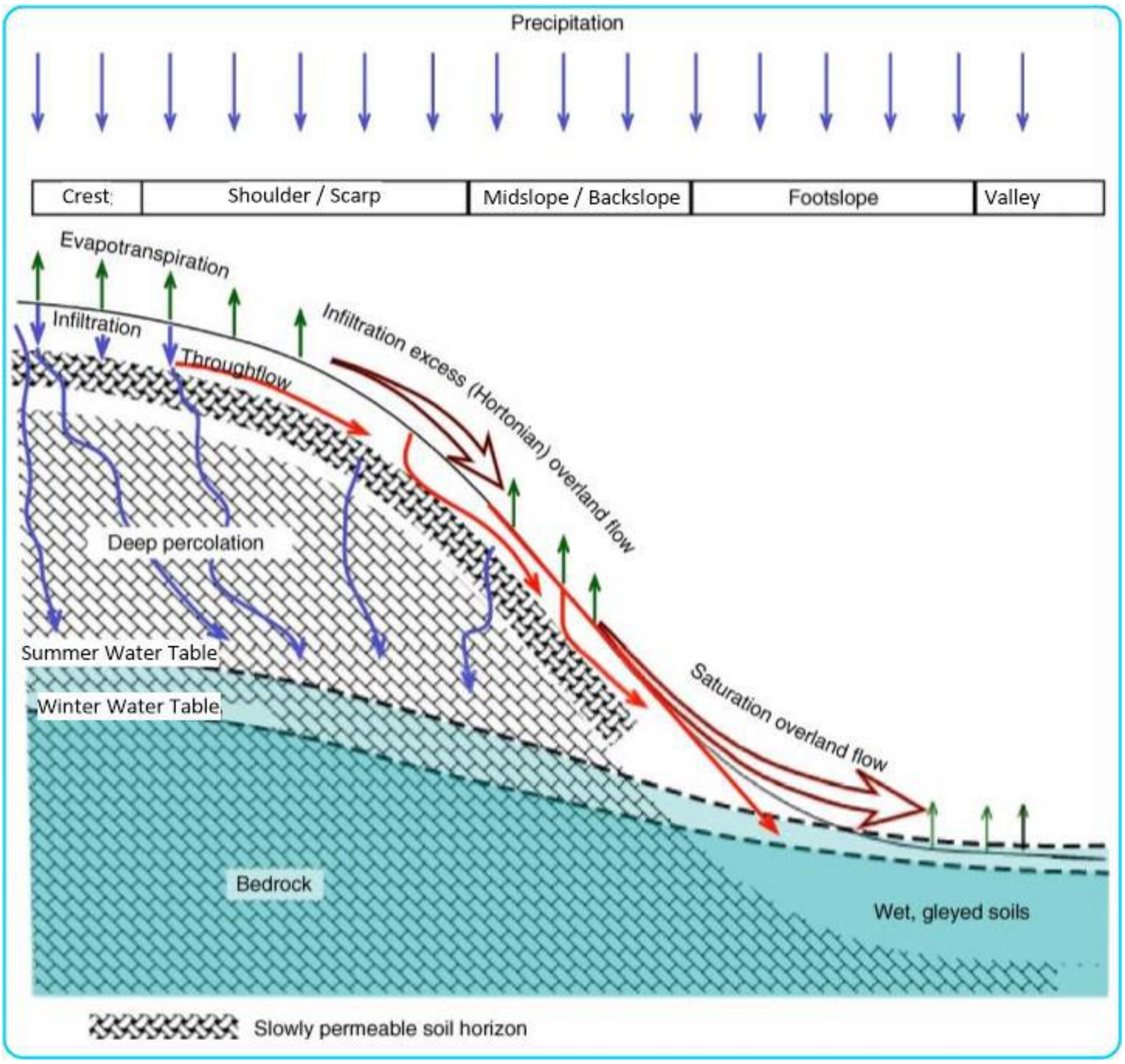


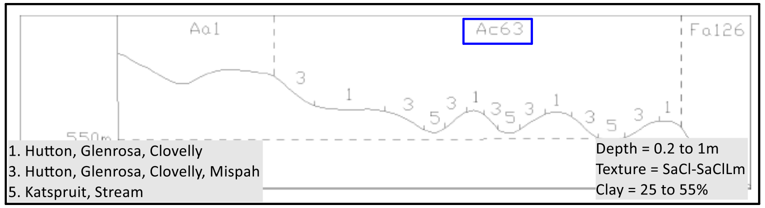
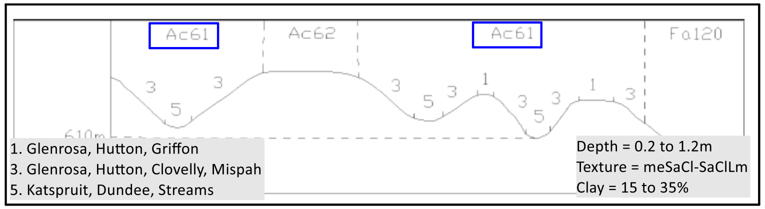
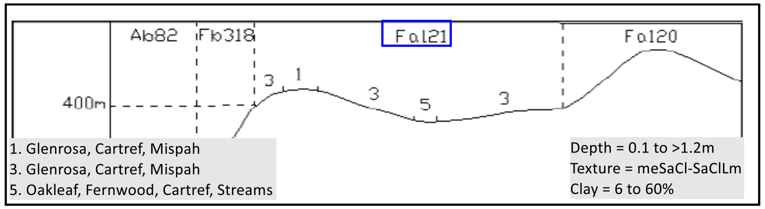
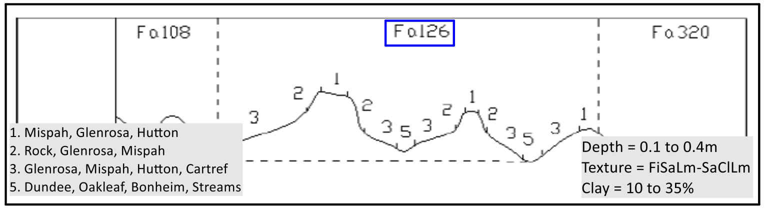
Figure 2-10: Land morphology concept (Almond, 2016)

Table 2-2: Land Types are known to be associated with the project area (See Table 2-3 for the explanation of the Land Types described in this table)

Area	Activity	Land Type
South Block	Processing Plant	Ac63, Fa126
	Incoming Power yard	Ac63, Fa126
	Primary Crusher	Fa126
	SE Pit	Fa126, Fa108
	Waste Dump	Fa126, Ac63, Fa127
	400kv Powerline	Ac63, Fa108, Fa126, Fa127, Fb322, Db151,
	Plant Access Road	Fa108, Fa126, Fa127, Fb322, Db151
	Overland Piping	Fa108, Fa126, Fa127, Fb322, Db151, Fb323
	All other areas in South Block	Ac63, Fa108, Fa126, Fa127, Fb322, Db151,
North Block	North Block mine area	Fa121, Fa120, Fa124, Ab82, Fb318, Fa128, Ac61
Outside South & North Block boundaries	400kv Powerline	Fa126, Fa 108
	Plant Access Road	Ac63, Fa126
	Overland Piping	Fa126, Fa127
	Railway Siding	Db151
	Raw Water Pump	Fb323

Based on Table 2-2 above, the following provides an overview of the main soil types occurring in the study area (ARC, 2006) – refer to Table 2-3.

Table 2-3: Summary of soils encountered in the project area

Description	Profile
• Land type Ac63 and Ac61 [Freely drained, red and yellow, dystrophic/mesotrophic, apedal soils comprise > 40% of the land type (red and yellow soils each >10%)]- refer to Figure 2-11 and Figure 2-12. • The dominant soil moisture regime in these soils is one of free drainage and leaching from the profiles. In the more arid areas, the leaching of salts is hindered by low precipitation (and subsequent evaporation of water from the profile) rather than poor drainage. The consequence is that these soils invariably don't exhibit mottling or redox morphology that would result from perched and/or fluctuating water tables. Wetland soils do occur in these landscapes but are generally limited to the immediate watercourse areas in depressions (Der Waals, 2019).	 **Figure 2-11: Ac63**  **Figure 2-12: Ac61**
○ Land type Fa121, Fa 126, Fa108, Fa127, Fa120, Fa124 and Fa128 and Ac61 [Shallow soils (Mispah & Glenrosa forms) predominate; little or no lime in landscape]- refer to Figure 2-13 to Figure 2-19. • The dominant soil moisture regime in these soils is one of free drainage and recharge of lower fractured rock layers. The degree of recharge depends on the extent and connectedness of fracturing in the underlying geology. Due to the dominance of rapid percolation through the fractured rock material signs of redox morphology are generally lacking except in cases where climate and the flow regime conspire to yield prolonged periods of wetness and saturation.	 **Figure 2-13: Fa121**  **Figure 2-14: Fa126**

<table>
<tr><th>Description</th><th>Profile</th></tr>
<tr><td>

- Under such conditions, the presence of redox morphology is accommodated at the family level in the Glenrosa form. Therefore, these landscapes do not have a clear expression of wetland conditions as a rule but specific cases may prove otherwise during detailed investigations. However, due to the “water capturing” function that rocky and shallow soils play they invariably contribute to the expression of wetness and wetlands further down the slope. In this regard in arid landscapes, the accumulation of lime in lower-lying landscape positions may indicate the preferential flow paths and hydrology even though these signatures do not qualify as wetlands per se (Der Waals, 2019).

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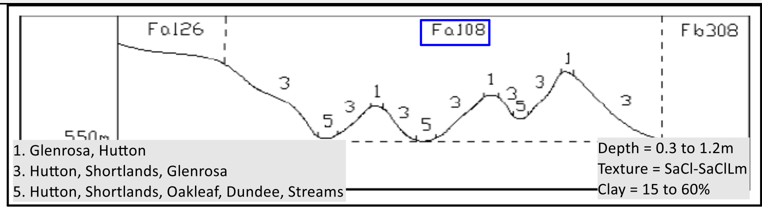

Figure 2-15: Fa108

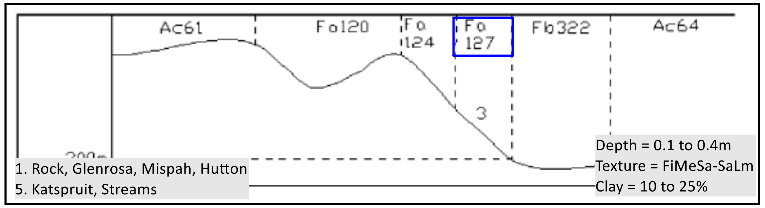

Figure 2-16: Fa127

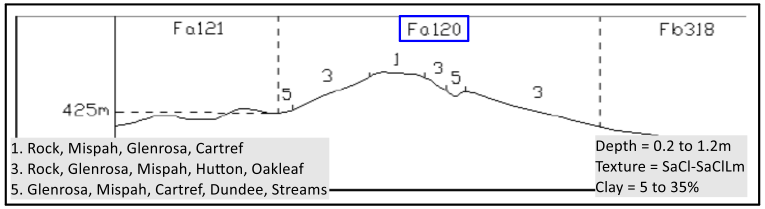

Figure 2-17: Fa120

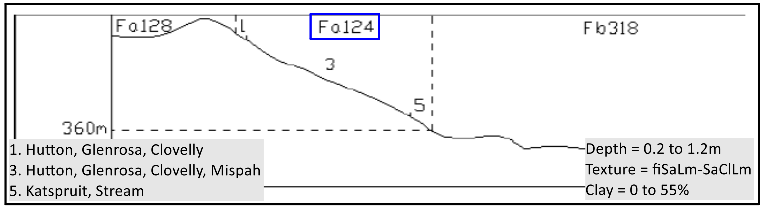

Figure 2-18: Fa124

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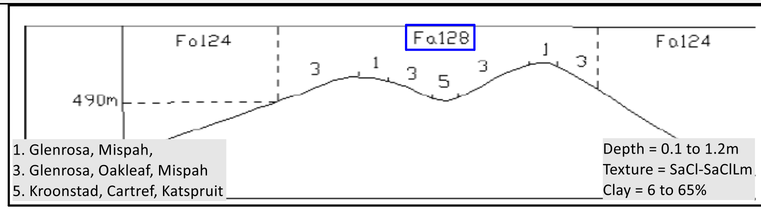

Figure 2-19: Fa128
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- Land type Fb322 and Fb318 [Shallow soils (Mispah & Glenrosa forms) predominate; usually lime in some of the bottomlands in landscape]– refer to Figure 2-20 to Figure 2-21.
- The dominant soil moisture regime in these soils is one of free drainage and recharge of lower fractured rock layers. The degree of recharge depends on the extent and connectedness of fracturing in the underlying geology. Due to the dominance of rapid percolation through the fractured rock material signs of redox morphology are generally lacking except in cases where climate and the flow regime conspire to yield prolonged periods of wetness and saturation. Under such conditions, the presence of redox morphology is accommodated at the family level in the Glenrosa form.
- Therefore, these landscapes do not have a clear expression of wetland conditions as a rule but specific cases may prove otherwise during detailed investigations. However, due to the "water capturing" function that rocky and shallow soils play they invariably contribute to the expression of wetness and wetlands further down the slope. In this regard in arid landscapes, the accumulation of lime in lower-lying landscape positions may indicate the preferential flow paths and hydrology even though these signatures do not qualify as wetlands per se (Der Waals, 2019).

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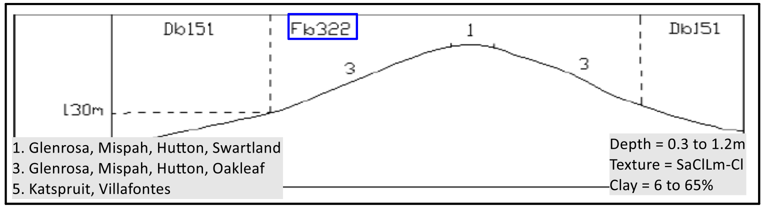

Figure 2-20: Fb322

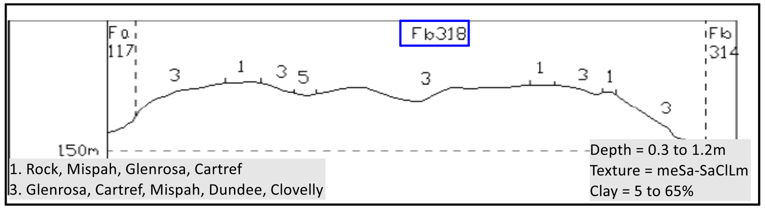

Figure 2-21: Fb318
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- Land type Ab82 [Freely drained, red and yellow, dystrophic/mesotrophic, apedal soils comprise >40% of the land type (yellow soils < 10%)]- refer to Figure 2-22.
- The dominant soil moisture regime in these soils is one of free drainage and leaching from the profiles. In the more arid areas, the leaching of salts is hindered by low precipitation (and subsequent evaporation of water from the profile) rather than poor drainage. The consequence is that these soils invariably don't exhibit mottling or redox morphology that would result from perched and/or fluctuating water tables. Wetland soils do occur in these landscapes but are generally limited to the immediate watercourse areas in depressions (Der Waals, 2019).

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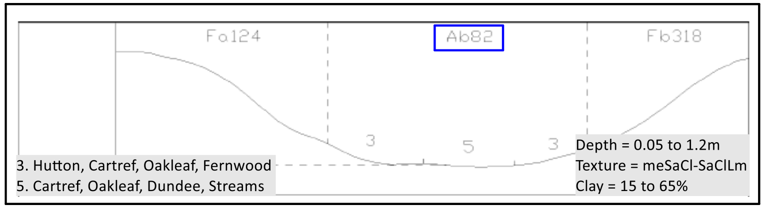

Figure 2-22: Ab82

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- Land type Db151 [Duplex soils (sandier topsoil abruptly overlying more clayey subsoil) comprise >50% of land type; < 50% of duplex soils have non-red B horizons]- refer to Figure 2-23.
- Duplex soils are characterised by a distinct difference in saturated and unsaturated hydraulic conductivity between the coarser overlying and higher clay content structured underlying horizons. In this regard, the coarser materials can accommodate more distinct lateral flows of water with its associated redox morphology in the form of bleaching and removal of sesquioxides. The structured subsoil horizon may exhibit a certain degree of redox morphology expression (redox depletions and redox accumulations) that can, in its maximal expression< lead to the classification of a G horizon in the lower parts of the landscape. Wetlands are often identified in areas with E horizons and shallow lateral seepage due to the perching of the water on the structured subsoil.
- Distinct water accumulation and lateral flows may also occur beneath the structured horizons in unconsolidated materials or fractured and weathering rock. In these cases, the redox morphology is consistent with the criteria used for wetland identification except for the depth criteria that preclude it from formal wetland identification (Der Waals, 2019).

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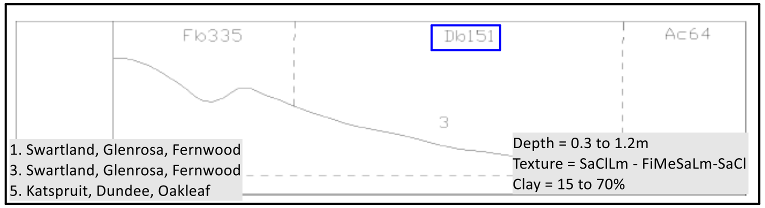

Figure 2-23: Db151

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2.7.1 Site-specific

A soil survey took place from 24 to 28 May 2021. Soil profile logs are available in **Appendix B**. The following is noted in terms of sub-surface soil conditions:

- 72 soil auger holes were conducted in the project area, targeting the dominant soil hillslope identified in the desktop phase. Moreover, a visual survey was undertaken in the study area targeting erosion gullies, rock outcrops where soil formation is visible and stream-eroded banks. The positions of the auger holes and the soils identified are shown in Figure 2-24.
- The Avalon soil form was encountered in 2 test holes. These soils are typically characterised by an orthic A horizon (apedal or slightly structured) followed by a yellow-brown apedal B sub-soil on soft plinthic (residual) soils. The soft plinthic horizon may promote soil/bedrock flow as a result of the hydromorphic properties associated with the soft plinthic horizon.
- The Clovelly soil form was encountered in 16 test holes. These soils are typically characterised by a shallow or deep orthic A horizon, followed by a yellow-brown apedal B horizon over unspecified material which can be both wet or dry. Field observations suggest that hydromorphic properties associated with the unspecified material may subject the soil forms to deep recharge of the sub-soils and underlying bedrock.
- The Glenrosa soil form was encountered in 31 test holes. These soils are typically characterised by shallow orthic A horizons (topsoils) followed by lithocutanic B (hard rock or weathered rock with some soil material giving rise to traces of in-situ weathering of bedrock). These soils will tend to promote overland flow due to the refusal of slightly weathered bedrock.
- The Hutton soil form was encountered in 18 test holes. These soils are typically characterised by shallow or deep orthic A horizons, followed by red soil formation (generally blocky structure or apedal) on top of unspecified material with or without traces of wetness. Field observations suggest that hydromorphic properties associated with the unspecified material may subject the soil forms to deep recharge of the sub-soils and underlying bedrock.
- The Katspruit soil form was encountered in 1 test hole. These soils tend to consist of shallow topsoil formations (orthic A) on a gleyic G horizon. The hydromorphic properties of the G horizon signify long periods of wetness, and the soils will act as responsive soils which may promote overland flow (generally these soils tend to produce wetlands).

- The Mispah soil form was encountered in 3 test holes. These soils are typical shallow topsoil soils overlying hard bedrock with no distinct in-situ weathering of the bedrock taking place. These soils will highly likely act as shallow responsive soils due to the limited topsoil thickness and hard bedrock layer.
- The Nomanci soil form was encountered in 1 test hole. This soil type was observed in an area where there was sufficient consolidation of vegetation in the soil profile. As such the soil generally consists of a Humic A horizon overlying a lithocutanic B horizon. These soils will likely act as shallow-responsive soils.

Generally, the predominant soil forms occurring in the study area are of the Glenrosa, Clovelly and Hutton soil families. These soil types were encountered in all areas associated with the project area, and also visually observed at outcrops and valley crosscuts. Photographs of soils encountered in areas associated with the conceptual layouts for the proposed site infrastructure, opencast pit and WRD are shown in Figure 2-25 to Figure 2-27.

2.7.2 Soil distribution

Figure 2-28 provides an estimate of the soil distribution for the study area. Soil occurrences were derived from available field data and extrapolated to areas based on available land type data and Google Earth Imagery (i.e. similar vegetation types relative to land morphology will likely have similar soils as per auger hole observation in investigated areas – data is extrapolated).

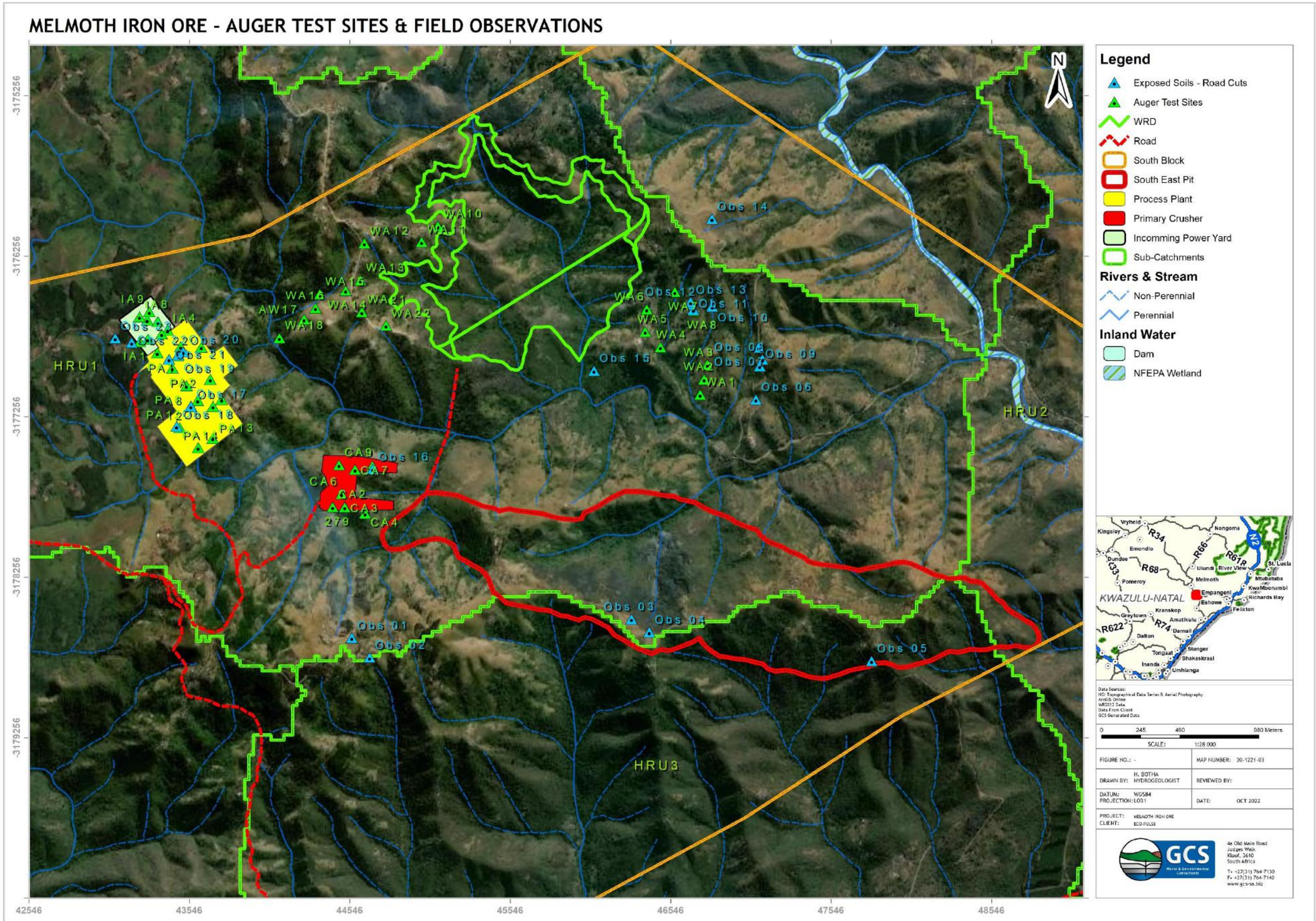


Figure 2-24: Soil survey areas

Figure 2-25: Soil observations – surrounding the proposed incoming power yard and processing plant

Figure 2-26: Soil observations – surrounding the proposed overburden dump

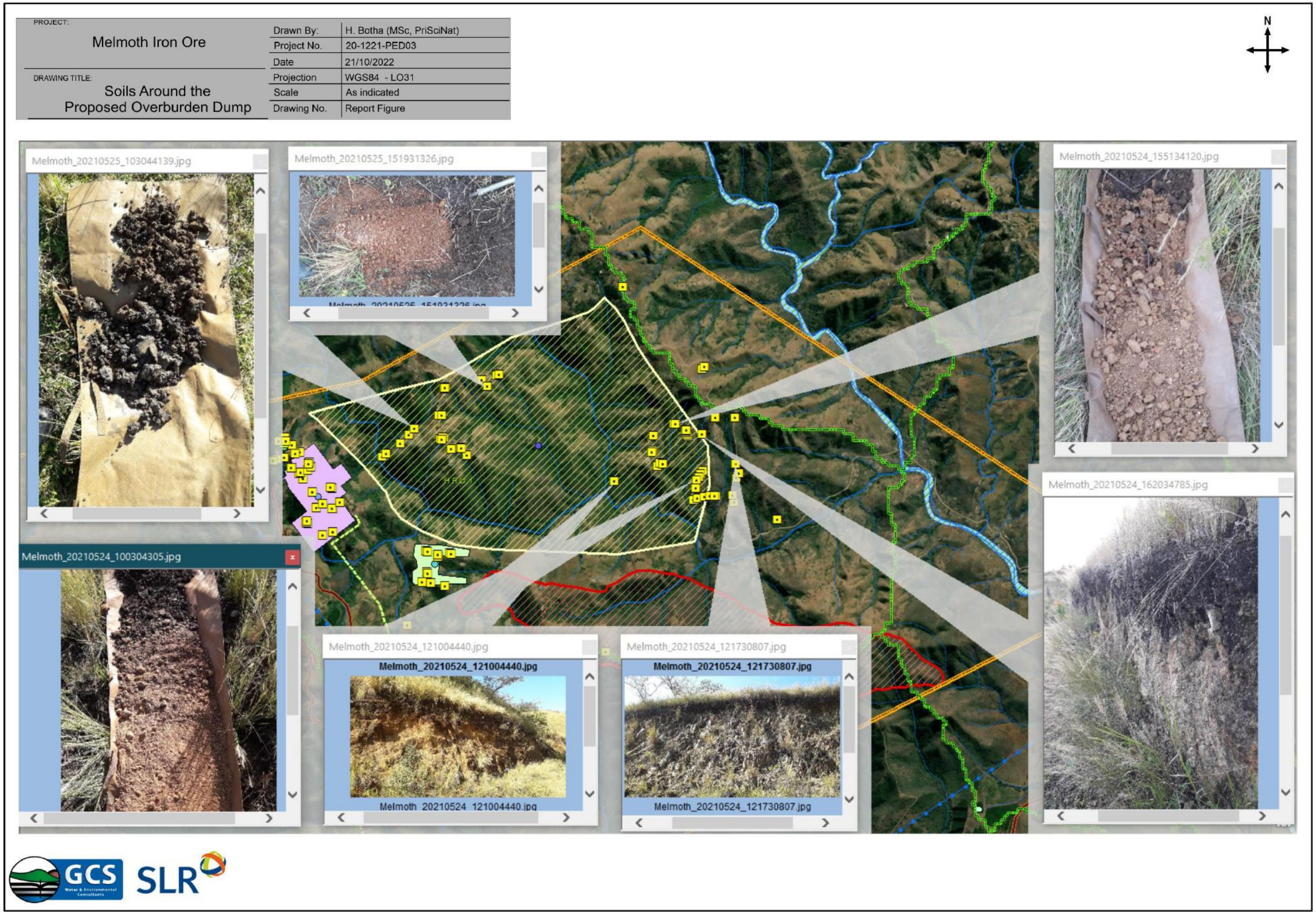


Figure 2-27: Soil observations – surrounding the proposed process plant and opencast area

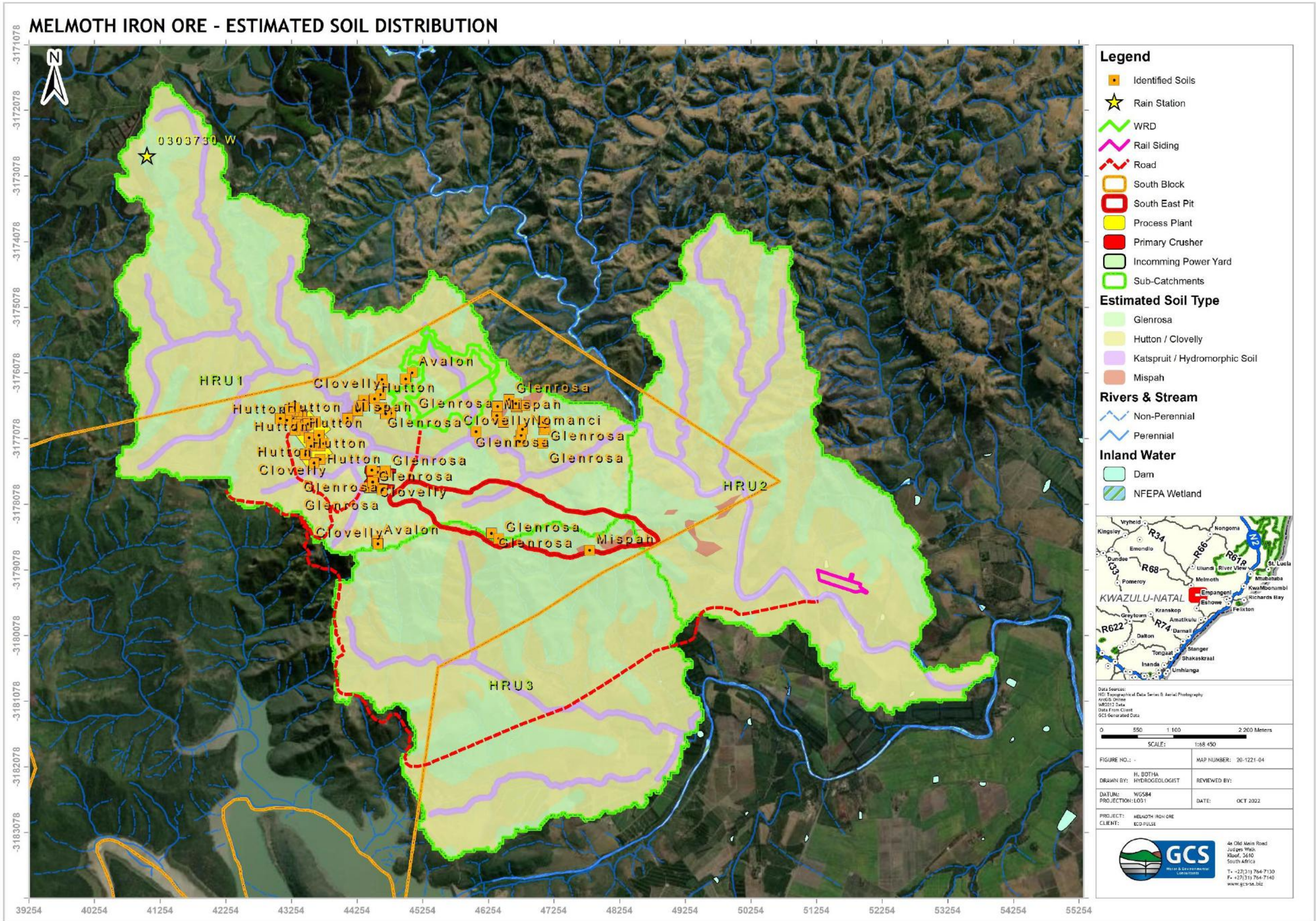


Figure 2-28: Estimated soil distribution

2.8 Soil permeability

Thirteen (13) composite soil samples (A to B horizon) were obtained from test auger holes and subjected to soil particle distribution testing (refer to **Appendix C**). Moreover, a series of falling head permeability tests were conducted on auger test holes in the waste dump, incoming power yard, primary crusher and process plant areas.

The approved budget for the hydropedology survey only included a limited number of soil samples. Due to the limited number of samples collected, the soil permeability estimates are considered preliminary. More samples should be taken before mining and the establishment of the surface infrastructure, to confirm soil permeability and potential impacts on the hydrological drivers relating to soil texture.

The soil particle testing suggests that the soils in the area predominantly consist of sandy (50% to 70% > 2000 µm particles) to sandy loam (20-30% > µm particles) soils – refer to Figure 2-30 to Figure 2-32.

Based on the permeability testing undertaken in the field (refer to **Appendix B**) the following soil permeability rates are expected:

- The drawdown observed in the test auger holes was evaluated per Infiltration Standards and Practices (ISRC, 2009) to establish soil coefficients of permeability.
- The soil permeability for test sites in the proposed waste rock dump area range from 1 to 5.8 m/day.
- The soil permeability for test sites in the proposed incoming power yard area range from 0.8 to 5.4 m/day.
- The soil permeability for test sites in the proposed crusher area range from 1 to 2.4 m/day.
- The soil permeability for test sites in the proposed process plant area range from 0.7 to 2.1 m/day.
- The coefficient of permeability for the soils in the project area, therefore, is expected to range from 0.7 to 5.8 m/day.

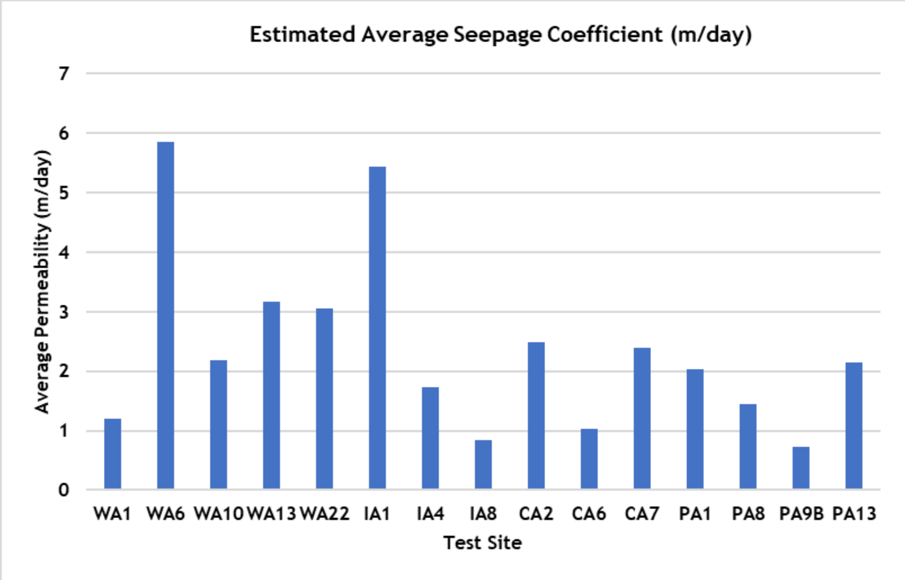


Figure 2-29: Coefficients of permeability for soils in the study area (ISRC, 31 July 2009)

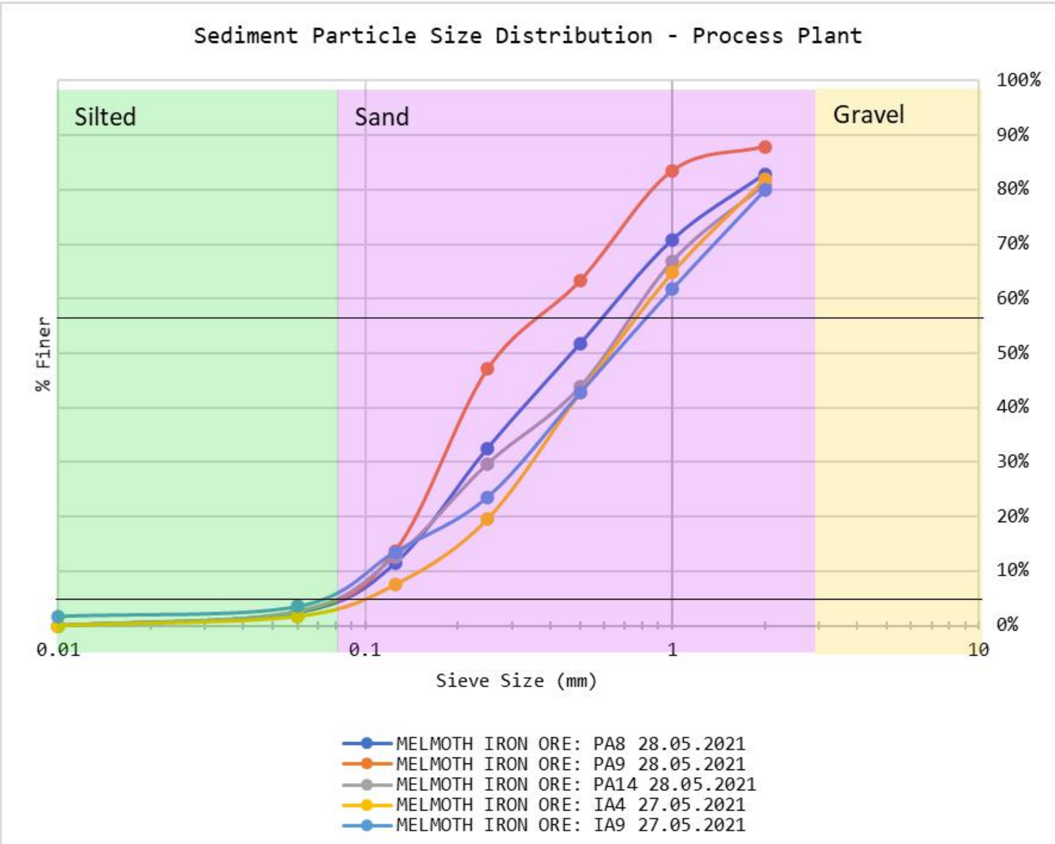


Figure 2-30: Soil particle distribution - Process Plant Area

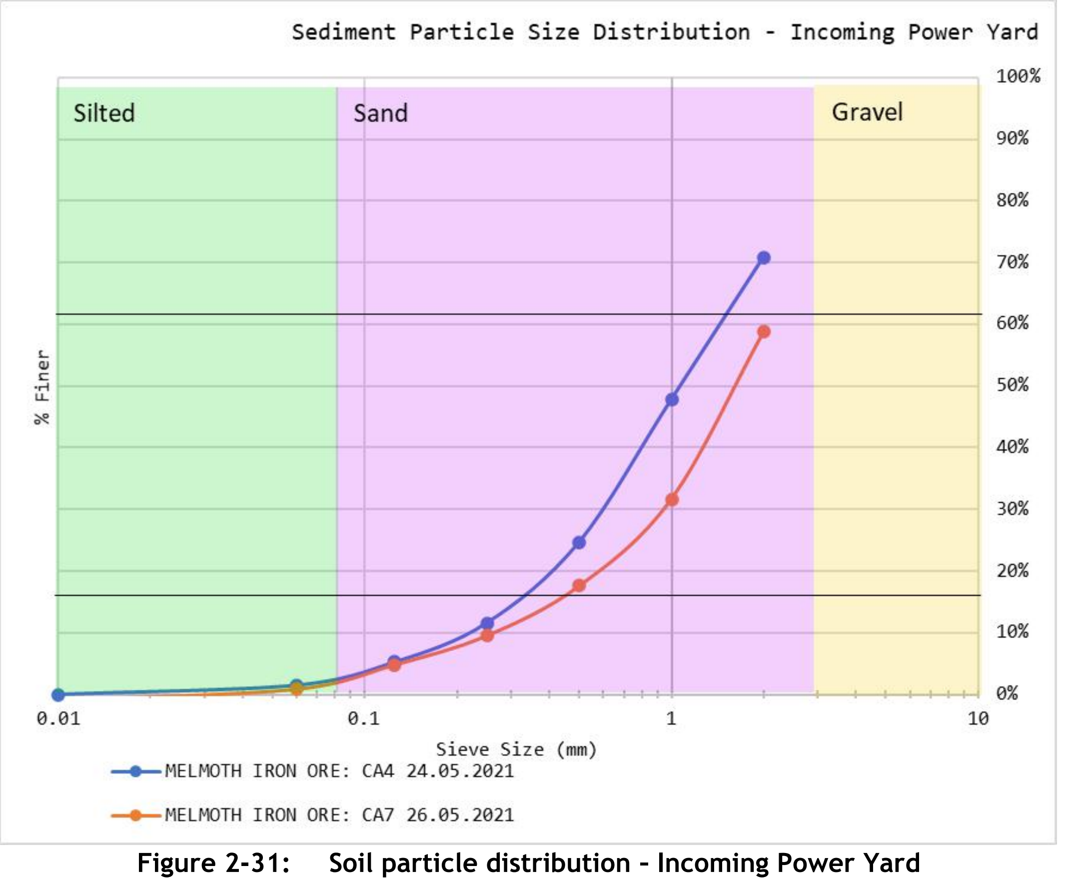


Figure 2-31: Soil particle distribution - Incoming Power Yard

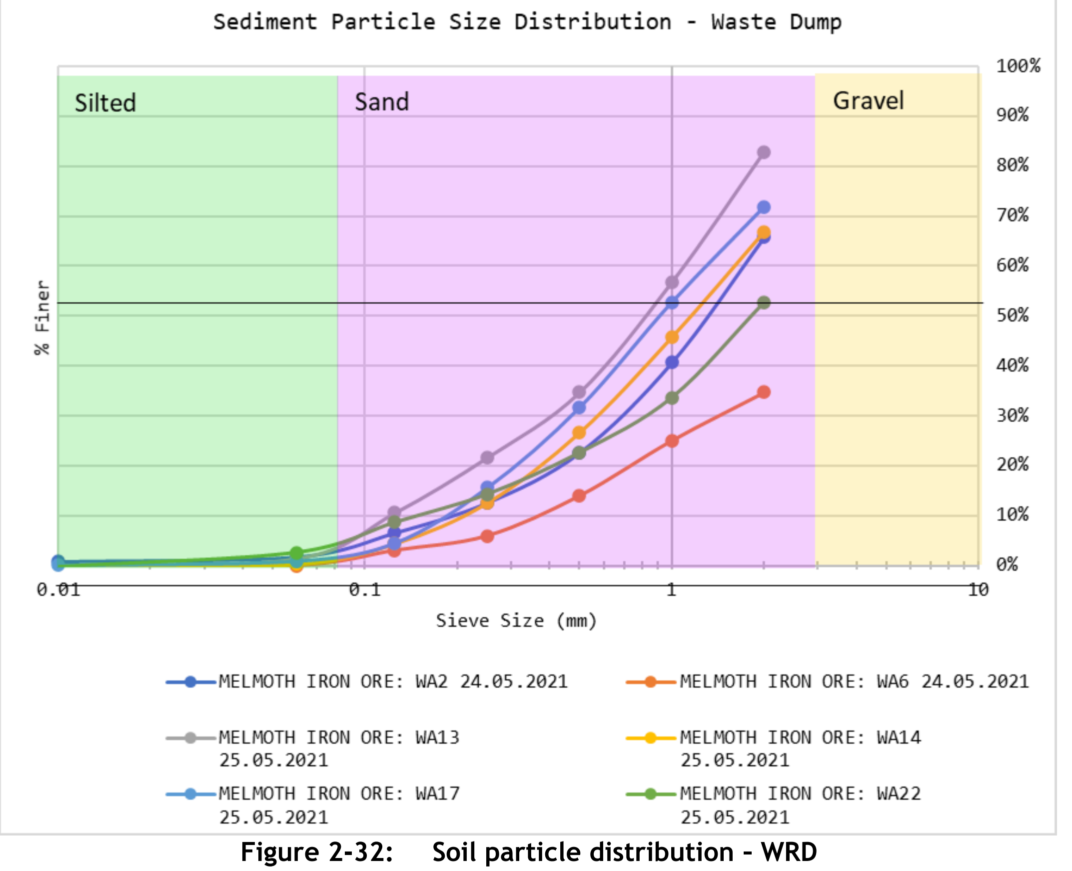


Figure 2-32: Soil particle distribution - WRD

3 HYDROPEDOLOGICAL ASSESSMENT

Soil genesis is influenced by physical and chemical water-related processes and soils are, therefore, the first-order control of hydrological processes. The water transfer function of soils varies with several factors including soil properties, topography, and climate.

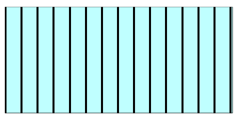
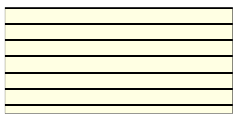
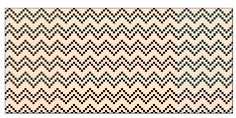
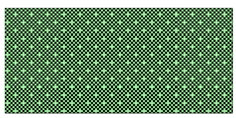
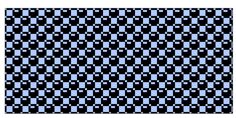
Characteristic soil properties make it possible to conceptualise hillslope hydrological responses within catchments. The approach followed in this study includes the classification of hillslopes for the site, and the development of a soil map (refer to Section 2.7), which was used to determine the HST. Finally, a conceptualization of hydrological processes that occur on the various hillslopes, based on HST was undertaken.

It was critical to determine hydropedological functions for soil, specifically for the proposed WRD, process plant, incoming yard and crusher, and opencast areas.

3.1 Hydrological Soil Types

In the determination of HST, soils were divided into classes based on their expected hydrological responses (Van Tol, et al., 2013). Hydrological processes were perceived from traceable signatures in the soil matrix resulting from the soil's ability to transmit, store and react with water (Le Roux, et al., 2011). The HST descriptions and representative symbols are presented in Table 3-1, below. HSTs identified in the project area are shown in Figure 3-1.

Table 3-1: Hydrological soil types

Hydrological soil type	Description	Symbol
Recharge	The soils do not have any morphological indication of saturation. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow path. These soils are deep and freely drained and are experiencing the leaching of nutrients to underlying soil horizons.	
Interflow (A/B)	The soils have a textural discontinuity which facilitates the build-up of water in the topsoil, the water that sits on the upper layer then flows laterally into the stream on the A/B horizon interface. The flow path is predominantly downslope in a lateral direction.	
Interflow (Soil/Bedrock) Or Interflow (A/ Bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify the temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	
Responsive (Shallow)	The soils are shallow, and they are over a relatively less permeable weathered rock or bedrock. They have limited storage capacity which results in the generation of overland flow after rainfall events.	
Responsive (Saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation.	

*Adapted from (Van Tol, et al., 2013)

3.2 Hillslopes and hillslope hydrology

Hillslopes and preferential soil flow paths were evaluated based on a 30m ALOS digital terrain model (DTM) (JAXA, 2021), and can be seen in Figure 3-1. The hillslopes generally feed into responsive soil types or streams/rivers.

Based on the soil HSTs in the study area, four (4) distinct hillslopes are considered. Hillslope 1 describes hydropedological processes for the conceptual footprint of the WRD. Hillslope 2 describes the hydropedological processes for the conceptual footprint areas of the incoming power yard and processing plant. Hillslope 3 describes the hydropedological processes for the conceptual footprint of the primary crusher and partially the WRD. Hillslope 4 describes the hydrogeological processes for the proposed SE opencast pit.

Similar HSTs in the study area (i.e. underlying the proposed pipeline, power lines, access roads and haul roads) will have similar hydropedological functions as per the hillslopes identified.

3.3 Conceptual hydrological flow processes

The hydrological processes associated with the land types and associated soils in the project (refer to Table 3-1) area are discussed using the numbered arrows (as the number in the paragraphs below) in Figure 3-2, and are generally similar for the hillslopes identified:

1. Most of the hillslopes are characterised by freely drained deep recharge soils of the Clovelly and Hutton soil groups.
    a. Shallow vertical and lateral recharge to sub-soils and lateral discharge towards responsive and interflow soil types are expected.
    b. Deep percolation into the sub-soils / hard rock and subsequent aquifers towards the lower topography areas is expected. This deep percolation water contributes to surface water streams as groundwater baseflow.
2. Soils associated with the crest/hilltops on the hillslopes are generally responsive (soil/bedrock) soils (Mispah, Glenrosa, Avalon and Mancini soil forms).
    a. Shallow hard rock or soft plinthic B horizons will signify a temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction will occur.
    b. In areas where bedrock has been subjected to fracturing secondary flow paths towards the groundwater table could exist. Water in the fractured zone will likely seep vertically down into the groundwater table.
3. The area associated with the valley bottom is associated with hydrogeomorphic soil types (such as the Katspruit soil form) and will primarily be responsive (saturated) or responsive (shallow) – depending on the degree of saturation.

a. In responsive soils, the build-up of water is expected in the B and upper A horizons after rain and overland discharge and minor lateral seepage are expected (due to saturation excess). Secondary vertical seepage to deeper soil zones from the saturated B horizon is expected. At the transition from one soil type to the other (upstream to downstream) overland flow may take place during wet seasons.

b. The release of water from the gleyic horizons will be somewhat slow and can still contribute to vertical and lateral water movement during dry periods.

c. A shallow vertical movement to sub-soils is expected.

4. Due to the likely presence of interconnected fractures within the bedrock, deep lateral movement of water is anticipated from high to low topography areas. However, this will depend on the degree of fracturing and interconnectivity between the vadose and saturated zones.

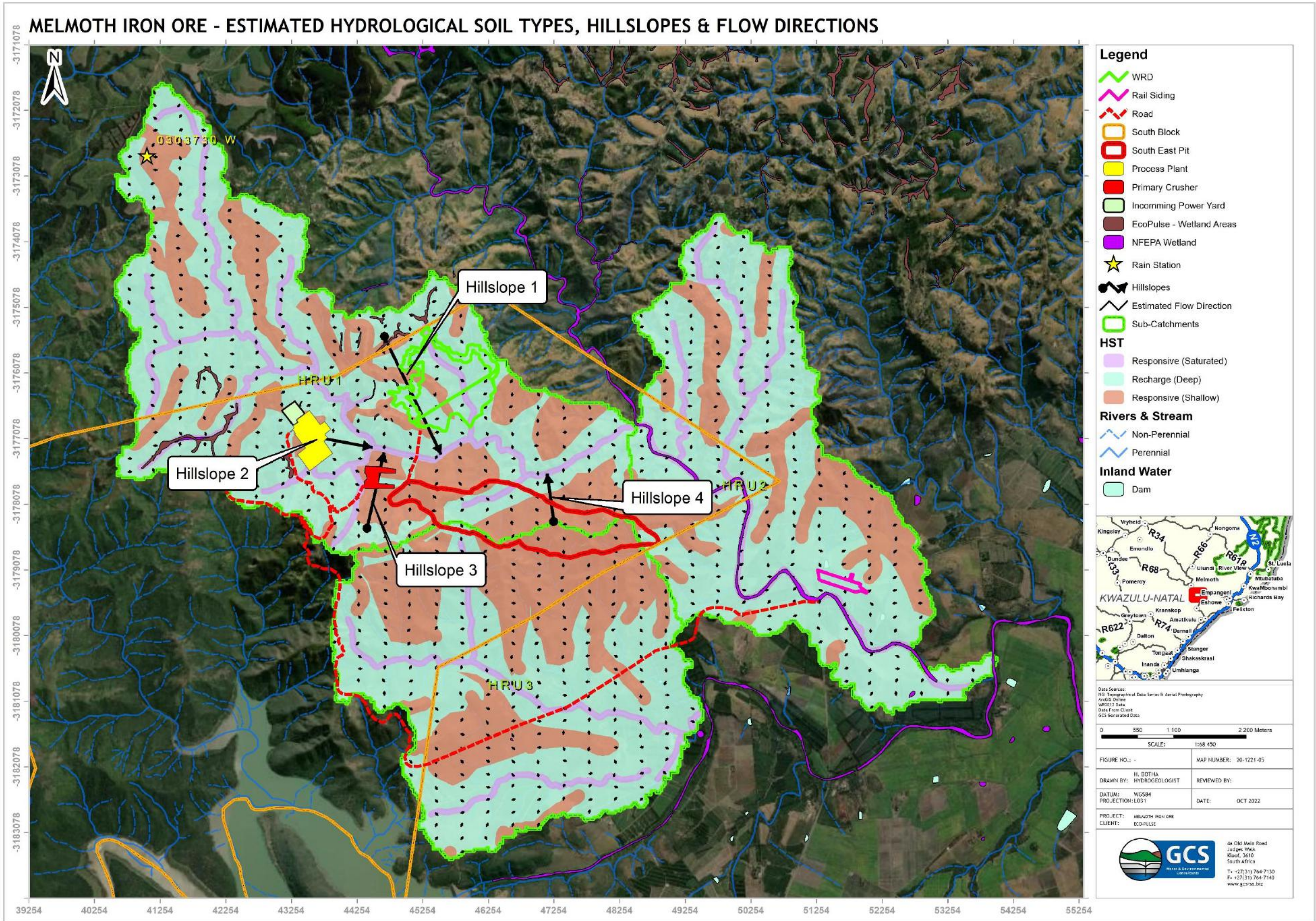


Figure 3-1: Estimated flow direction, hydrological soil types (HSTs) and hillslopes for the project area

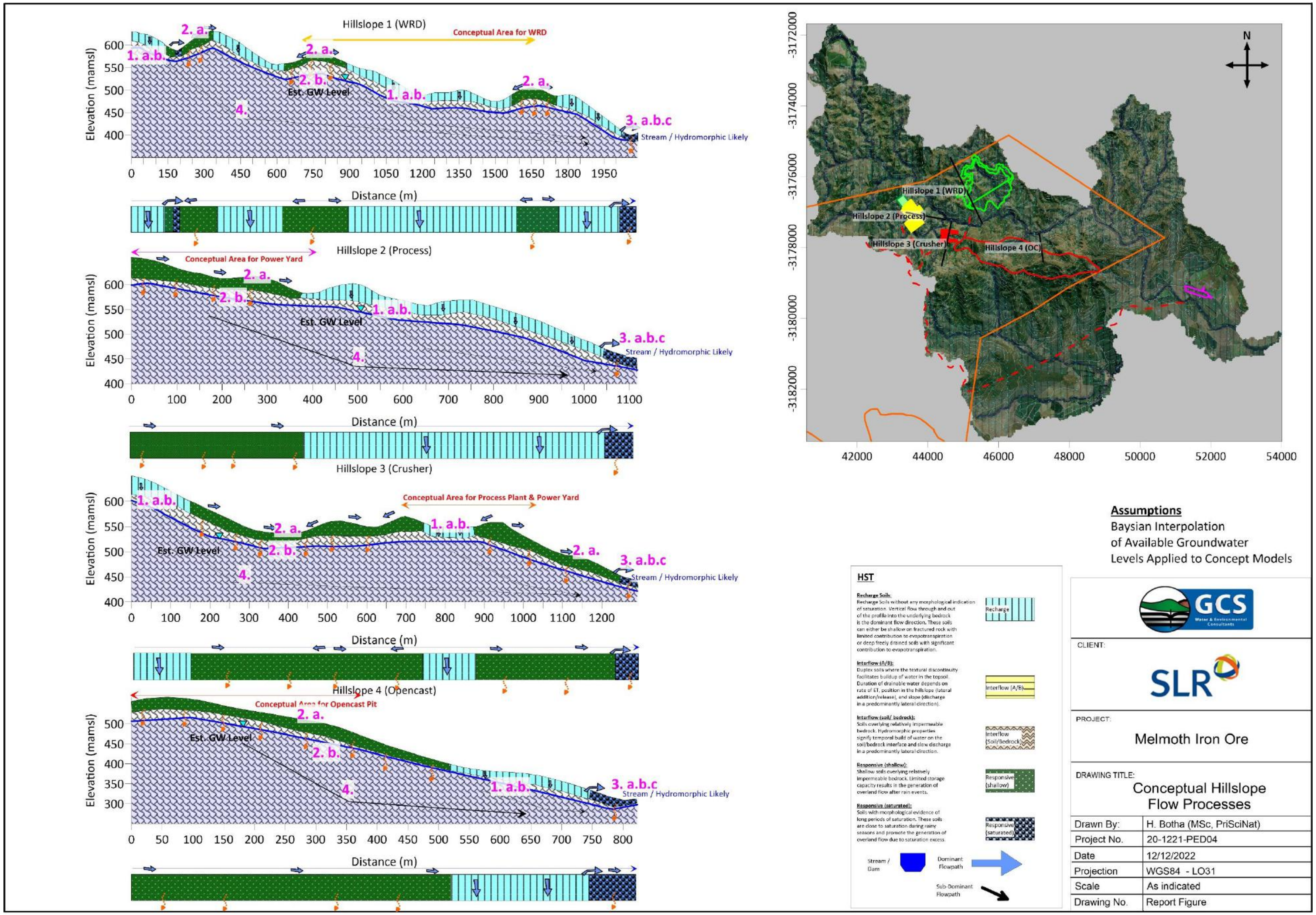


Figure 3-2: Hillslopes and conceptual flow processes

4 PRELIMINARY IMPACT AND RISK ASSESSMENT

The proposed project will take place in a Greenfields area. Hence, no existing impacts are anticipated. The impact on the hydropedological functions is founded on basic principles of geo-hydrology (Harbaugh, et al., 2000) and hydropedology (Job & le Roux, 2019; Job, et al., 2019; Le Roux, et al., 2011).

The general hydropedological flow drivers, and coupled geohydrological processes, for a natural setting are presented in Figure 4-1, below.

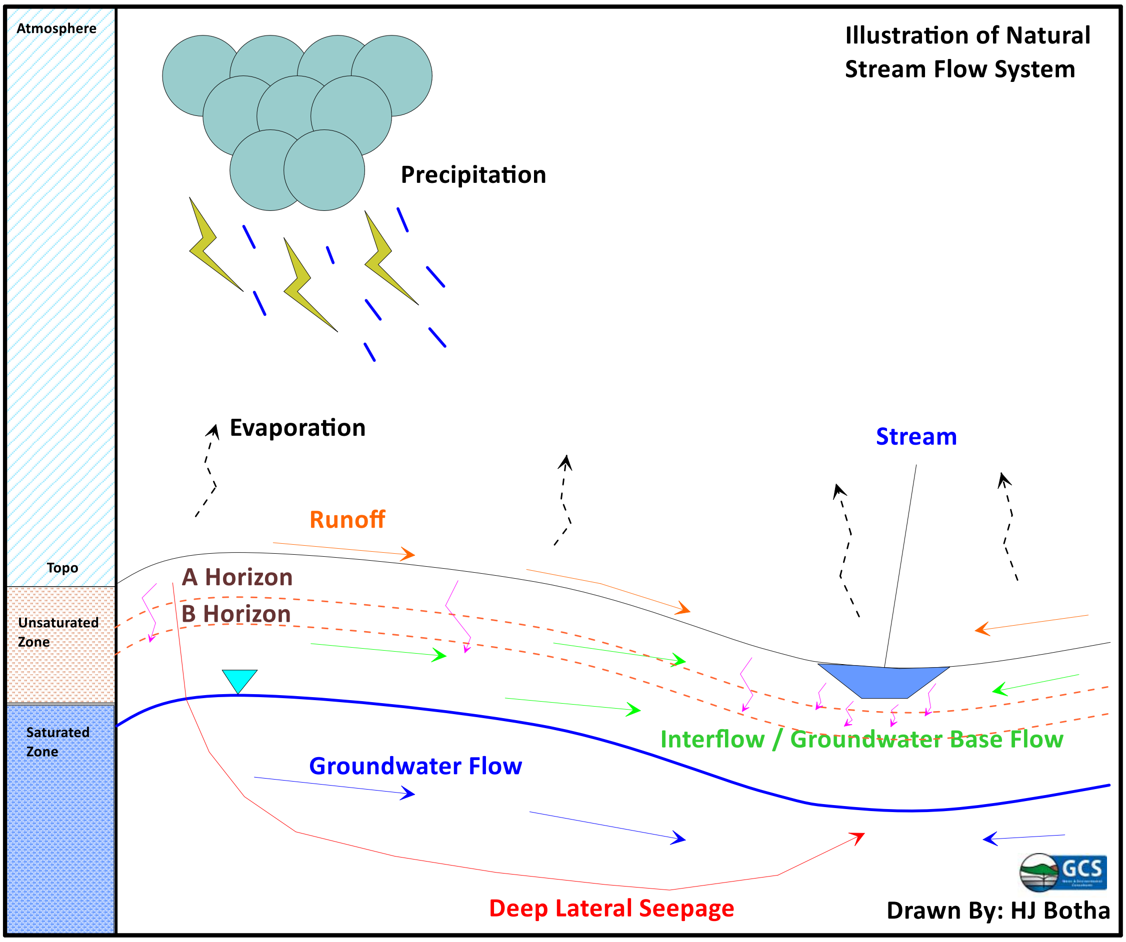


Figure 4-1: Natural flow drivers

It can be seen that the main hydrological processes in a non-mining setting are:

- Atmospheric zone:
  - Precipitation;
  - Runoff; and
  - Evaporation.
- Unsaturated zone:
  - Infiltration;

- Interflow (soil capillary rise, percolation, vertical soil water flow); and
- Groundwater baseflow (lateral soil water possibly saturated lateral groundwater flow – in areas where shallow groundwater levels occur).

- Saturated zone:
  - Deep lateral seepage; and
  - Groundwater flow (baseflow and aquifer flow).

In an opencast mining setting (during mining and post-mining), the hydrological process will be altered and is presented in Figure 4-2, below.

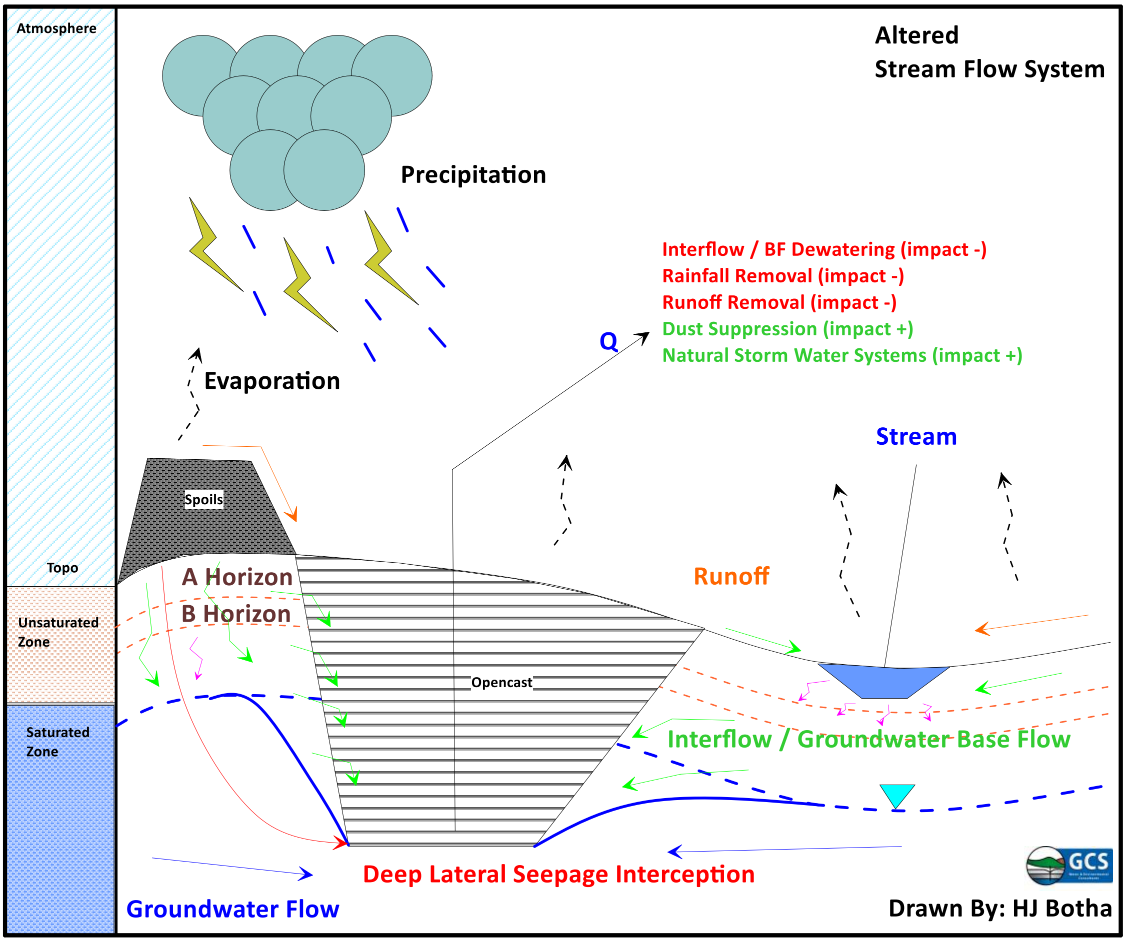


Figure 4-2: Altered flow drivers - opencast mine

The following components will highly likely be impacted and will depend on the geomorphology and HSTs of a specific sub-catchment and associated hillslopes, namely:

- Interflow (vertical or lateral or both) will be intercepted and removed;
- Groundwater flow and deep lateral seepage will be intercepted and removed;
- Runoff from the upper reaches of the sub-catchment will be intercepted and removed (if not diverted); and
- Direct rainfall into an opencast working will be pumped out.
- Runoff from WRD will most likely be free draining back to the environment. However, where the WRD is situated there may be reduced vertical percolation into the sub-soils/ Alteration of the natural hydrogeological flow processes are likely to occur.

4.1 Flow driver impact categories

Table 4-1 summarises the criteria used for the hydropedological flow driver impact assessment. The flow driver impact assessment aims to characterise the likely impacts post-mining (i.e. what is the likely impact of land development/dewatering/mining on the hydropedological flow drivers sustaining a wetland or stream after the development has taken place).

Table 4-1: Impact categories for describing the impact on the wetlands and associated hydropedological drivers

Severity	Flow Driver Reduction	Change Class	Description
No Impact	0 - 2.5 %	No change	The hydropedological process is predicted to be unmodified and the functionality of the wetland will remain unchanged
Low	2.5 - 5 %	No Significant change	A small effect on the hydropedological process is predicted, however, the functionality of the wetland remains unchanged and no change in resource class is expected.
Low to Moderate	5 - 10 %	Limited change with a change in the PES category is possible	A slight change in hydropedological processes is predicted and a small change in the wetland may have taken place but is changed to the (present ecological state) PES, EIS (ecological importance and sensitivity) or wetland functionality and eco service provision is limited with no more than one PES class predicted.
Moderate	10 - 15 %	A significant change with a change in PES Category definite and possibly a change of more than one category	A moderate change in the hydropedological processes is predicted to occur, the change in PES may exceed one category but no change in EIS takes place. No loss of important eco-services is predicted to occur

Severity	Flow Driver Reduction	Change Class	Description
High	15 - 22.5 %	A very significant change with a change in PES of more than two categories	Modifications have reached a very significant level and the hydropedological processes are predicted to be largely modified with a large change in the PES, and EIS of the wetland feature as well as a significant loss in eco service provision.
Very High	22.5 -60%	Serious to Critical change with a change in PES of more than three categories or a permanent complete loss of wetland resource	Modifications have reached a serious level and the hydropedological processes have been seriously modified with an almost complete loss of wetland integrity, functionality, and service provision.

4.2 Flow driver loss calculation/impact estimation

A water balance approach was adopted to estimate the potential impacts on the flow drivers. The equation used was as follows:

$$\text{Flow Loss \%} = \frac{FN\ (\text{m}^3/\text{yr.})}{\text{WT}\ (\text{m}^3/\text{yr.})} \text{ x } 100 \text{ (convert to \%)}$$ Equation 1

Where:

- FN = Sum of Total Negative flow driver impacts in a given sub-catchment.
- WT = Total water in the system.

And:

$$FN = RRI + GBR + AII + NRF$$ Equation 2

- RRI = Est. direct rainfall runoff intercepted by the mine and associated infrastructure (m^3/yr.).
- GBR = Est. reduced groundwater contribution to flow drivers / GW dewatering (m^3/yr.).
- AII = Est. aquifer and soil interflow intercepted by the development/activity (m^3/yr.); and
- NRF = Est. surface runoff intercepted which would naturally flow from upper catchments to the downstream environment (m^3/yr.).

Adding positive water releases to the flow driver system (i.e. diverting rainwater to the environment via stormwater systems) may offset the negative. The equation used, was as follows:

$$\text{Net Flow loss impact (\%)} = [\mathbf{\Sigma Total\ Negative}\ \text{flow driver impacts } (m^3/yr.) - \mathbf{Positive\ Adjustments}\ (m^3/yr.)\ ] / \text{Total water in the system } (m^3/yr.) \times 100 \text{ (convert to \%)}$$ Equation 3

<u>Where:</u>

The Sum of Positive Adjustments (m^3/yr.) are:

- Est. positive flow releases previously impacted (m^3/yr.); and
- Est. new positive flow releases not impacted on (m^3/yr.).

4.2.1 Assumptions

The following assumptions were made:

- Evaporation is assumed to be the remainder of the water balance, after acclimation of rainfall, groundwater recharge and runoff.
- Groundwater dewatering is assumed to be zero, due to the proposed shallow mining depths.
- Groundwater contribution to baseflow is assumed to be in the order of 43 mm/yr (5% of the annual recharge).
- Interception of surface water runoff and interflow from upstream topographical areas (relative to the proposed infrastructure) is included in the balance.
- It is assumed that 80% of all direct rainfall at the site (at all infrastructure areas) will be conveyed back to the natural environment via stormwater systems. It is further assumed that water ingress into the pits and direct rainfall will be pumped to the PCDs or attenuation ponds (depending on quality). Runoff from the WRD will likely be free to flow back to the environment.
- No artificial recharge, other than in the case of a mitigation measure, is accounted for.
- The existing setting and activities are evaluated. Built-up areas are assessed as being impermeable or no-flow boundaries. This was done to evaluate the likely impacts of the activities on the nearby watercourses and the likely change in PES/EIS for the quaternary catchments.

4.2.2 Flow driver impact calculations

The flow driver impact estimates for the identified hillslopes and sub-catchments are shown in Table 4-2, below. The estimates are based on the assumptions and equations above.

Table 4-2: Flow driver impact estimation calculations

		Rainfall	HRU1	HRU2	HRU3
		mm/yr	848	848	848
		GW Recharge	**HRU1**	**HRU2**	**HRU3**
		%	5.1	5.1	5.1
		mm	43.248	43.248	43.248
		Sub-Catch Area	**HRU1**	**HRU2**	**HRU3**
Drivers	**Status**	km²	28.12	19.87	20.73
Natural Water Processes					
	+	Total Rain Volume (m³/yr)	23843088.8	16851286.4	17579133.3
	-	Runoff (m³/yr)	1192154.4	842564.3	878956.7
	-	BF (m³/yr)	1215997.5	859415.6	896535.8
	-	Evap (m³/yr)	21434936.8	15149306.5	15803640.8
		Balance	0.0	0	0
Description		**Impacts**	**HRU1**	**HRU2**	**HRU3**
The area that becomes impermeable or altered.		Est. Distrubance Area (km²)	3.5200	0.1080	0.8000
		Est. Intercepted Flow Area (km²)	0.0465	0.00018	0.0465
		Est. Groundwater Dewatering (m³/yr)	0	0	0
		Est. Dewater/Decant Rate	**HRU1**	**HRU2**	**HRU3**
		m³/day			
Drivers	**Status**				
Impacted Processes	-	Rainfall Intercepted (m³/yr)	2984960.0	91584.0	678400.0
	-	BF Reduct (GW Dewatering) (m³/yr) = Groundwater To Deep	0.0	0.0	0.0
	-	Interflow Removed (m³/yr) = Assume depth of 15 max, associated with shallow OC strip Mine	2011.0	7.8	2011.0
	-	Intercepted Runoff (m³/yr) = ZERO (assume diverted to nearest watercourse)	0.0	0.0	0.0
	+	Storm Water (m³/yr)	2387968.0	73267.2	542720.0
		Negative Impacts	2986971.0	91591.8	680411.0
		% Impact on Natural Flow System	12.53%	0.54%	3.87%
		% After Storm Water Convey	2.51%	0.11%	0.78%

4.2.3 Estimated flow losses and risk rating

Based on the sub-catchments delineated and proposed activities, the overall impacts on the sub-surface natural flow systems were estimated. Table 4-3 summarises the estimated % loss ratings for the sub-catchments – pre- and post-mitigation. The flow drivers represent the cumulative impacts of all mining-related activities associated with the sub-catchment delineated.

As most of the mining will take place in HRU1, the predicted impact on the PES / EIS for watercourses associated with this HRU is “Moderate”. This is largely due to the size of the proposed WRD and the net results of all the activities taking place in one sub-catchment. If the mine footprints are reduced, the impact on PES / EIS should decrease.

The predicted impact for HRU2 and HRU3 is “No impact” and “Low” (respectively), as only a small portion of the SE Pit falls in these sub-catchments.

After considering likely stormwater attenuation discharge back to the environment (as part of mitigation measures proposed); the impact on PES and EIS changes to “Low” and “No impact”.

Table 4-3: Estimated % Loss rating for micro-catchments (sub-catchments)

Sub-Catchment	Est. Flow Driver Impact (No Mitigation)	Severity	Est. Flow Driver Impact (Mitigation)	Severity
HRU1	12.53%	Moderate	2.51%	Low
HRU2	0.54%	No Impact	0.11%	No Impact
HRU3	3.87%	Low	0.78%	No Impact

4.3 Hydropedological risk identified

The anticipated hydropedological risks and impacts concerning the proposed and post-development activities were assessed.

The source-pathway-receiver (SPR) model (DWAF, 2008) was used to evaluate potential pollution sources and primary receptors within the study area (underlying soils, watercourse and groundwater table). The risk assessment methodology and ratings applied are available in **Appendix A**.

The potential impacts identified and environmental significance for the preparation, mining and closure phase are summarised in Table 4-4 to Table 4-6.

Based on the available conceptual mine layout plans the following will likely contribute to impacts of hydropedological flow drivers, and soil quality and may compromise surface water quality in the nearby watercourse:

4.3.1 Impacts on the soil interflow processes, soil structure and land capability

There is potential to impact the soil interflow processes, namely:

- Alteration to natural hydropedological flow paths by infilling or cut and fill activities.
- Impacts on the macro-soil structure.
- Impacts on the hydropedological processes supporting the watercourses.

This will result in subsequent impacts on soil structure & land capability and could compromise soil quality. These impacts are expected from the preparation to the closure phase of the project. There is the potential for soil contamination and suppression of natural hydropedological flow drivers in areas associated with the proposed crusher, processing plant, access roads, pipeline, WRD and opencast operations. Potential contaminants from the project are expected to include construction-related consumables, fuels, hydrocarbons, residues and hazardous wastes. A waste classification will be undertaken for the EIA as well as to inform the final design of the secured landfill facility and liner requirements. In the absence of mitigation, however, the intensity of unmitigated impacts would be high, particularly for the suppression of the natural hydropedological flow drivers and that relating to soil quality. In time, reduced soil water quality could be reversed, however, at this stage, the related period is not known. The related unmitigated significance is, therefore, moderate. Important to note is that the use or potential contamination of water resources is regulated through Water Use Licensing requirements of the DWS as the custodian of water resources in South Africa. Where the project plan takes into account the findings of specialist studies, applies the necessary mitigation to avoid, minimise or remedy impacts in line with the mitigation hierarchy and operates under a water use license, the significance of potential impacts can be reduced.

The following activities may contribute to these impacts:

- **Preparation (pre-mining) phase:**
    - Site preparation, including placement of contractor laydown areas and storage (i.e. temporary stockpiles, bunded areas etc.) facilities.
    - Disturbing vadose zone during soil excavations / infilling activities.
    - In-situ placement of new soils, altering existing soil-flow processes (i.e. cut-and-fill areas).
    - Linear developments (pipelines, electrical pylons & transmission lines and roads associated with the project) will likely not have a major impact on hydropedology as these structures entail disturbing a very shallow or small surface area – with regards to the mining activities. However, soil compaction due to road and pipeline installations, and the movement of heavy vehicles and mining machinery is highly likely to occur.
    - Vegetation loss will likely decrease soil infiltration and increase runoff, which will likely increase erosion.
- **Operational (mining phase):**
    - Surface water interception and reduced rainfall runoff to watercourses and drainage servitudes (i.e. this water will be captured by the WRD, crusher process plant and power yard stormwater systems or opencast workings).
    - Shallow lateral water seepage and percolation are associated with the opencast operation. The mining will entail strip mining (*actual depths of the pit are not available as designs are conceptual*) and it is anticipated that limited removal of deep lateral water seepage may occur (i.e. the cone of depression will be limited to the maximum depth of the mine works).
    - Decreased groundwater recharge due to interception of natural soil water occurrences and dewatering.
- **Closure / decommission phase**
    - The activities will generally entail rehabilitation and site clean-ups, whereby the aim would be to restore natural flow processes. Similar impacts to those associated with the commissioning phase are anticipated but will be limited to areas that are further disturbed/rehabilitated.
    - The following is anticipated and assumes that the opencast pit will be backfilled, the processing yard, crusher and power yard will be removed and rehabilitated, and that most of the waste rock will go back into the pit with the remnant remains being rehabilitated:

- New hydropedology flow regimes will form as a result of the backfilled opencast pit. Backfill material properties will not be similar to the in-situ soil properties, and will likely promote interflow from the pit into the surrounding areas.
- The soil at the power yard, processing plant and crusher area will likely be compacted, even after the structures are removed. Hence, post-closure hydropedological flow in these may be subjected to overland flow and less interflow.
- Waste rock not used for the pit backfilling activities will likely be retained within the conceptual laydown area. Unrehabilitated and rehabilitated waste rock dumps will likely induce greater runoff into the surrounding areas, rather than promote pre-mining interflow. This may lead to the sedimentation of nearby watercourses.

4.3.2 Reduced hydropedological flow to surface water (perennial & non-perennial streams and wetlands) as well as impacts on soil and water quality

There is potential to impact the water quality and quantity of watercourses/wetlands sustained by the hydropedological flow, using suppression or alteration of the natural flow as a result of the mining activities. Moreover, contamination of soils during the project may compromise water

- **Preparation (pre-mining) phase:**
  - Soil & surface water contamination and sedimentation from the following activities:
    - Leakages from vehicles and mine machines, and seepage from mine materials (i.e. construction material for permanent facilities, cement, paint, etc.).
    - Erosion and sedimentation of watercourses as a result of mine preparation activities, stockpiling and initial mining phase due to unforeseen circumstances (i.e. bad weather); and
    - Alteration of natural drainage lines may lead to ponding or increased runoff patterns (i.e. may cause stagnant water levels or increase erosion).
  - Vegetation loss will likely decrease soil infiltration and increase runoff, which will likely increase erosion.
- **Operational (mining phase):**
  - Soils/mining material placed near watercourses may be prone to causing erosion and sedimented runoff if high precipitation occurs in the area. It may take some time for these areas to stabilise (i.e. to establish new interflow soil dynamics).
    - There may also be secondary seepage from these mine materials/soils which could impact soil-water quality.
  - Dumping waste rock on top of soils and in or near watercourses will likely have an impact on the soil flow dynamics.
    - For wetland areas identified by Eco-Pulse (2021), infilling may change flow volumes (as the material will likely become dry over time) and new predominant soil flow processes will form (i.e. form responsive to interflow type). Similarly, if the waste rock is placed upstream of identified wetlands there may be more runoff into the wetlands, altering the natural flow system.

    - Watercourses in the area (mainly perennial streams as non-perennial streams in this area tend to be ephemeral) may be subjected to receive less interflow, or more interflow, depending on the position of the placement of the waste rock (i.e. infilling of drainage line will cause suppressed natural interflow, as opposed to upstream which could promote interflow but likely increase runoff).
  - Surface water interception and reduced rainfall runoff to watercourses and drainage servitudes (i.e. this water will be captured by the WRD, crusher process plant and power yard stormwater systems or opencast workings).
  - Shallow lateral water seepage and percolation are associated with the opencast operation. The mining will entail strip mining (*actual depths of the pit are not available as designs are conceptual*) and it is anticipated that limited removal of deep lateral water seepage may occur (i.e. the cone of depression will be limited to the maximum depth of the mine works).
  - Decreased groundwater recharge due to interception of natural soil water occurrences and dewatering.
  - Soil pollution through nutrient leaching from crushed rock into underlying soils.
  - Soil quality could be compromised if oil & fuel spills from vehicles occur.
  - Increased runoff from the process plant, crusher, power yard and WRD could impact surface water quality in nearby watercourses and may further change hydropedological functions of the soils associated with the watercourses (i.e. may promote hydromorphic changes after long exposure periods [> 1 to 2 years]).
- Soils in contact with the new watercourse will become saturated, and with time may change the soil morphology.

- **Closure / decommission phase:**
  - The activities will generally entail rehabilitation and site clean-ups, whereby the aim would be to restore natural flow processes. Similar impacts to those associated with the commissioning phase are anticipated but will be limited to areas that are further disturbed/rehabilitated.
  - The following is anticipated and assumes that the opencast pit will be backfilled, the processing yard, crusher and power yard will be removed and rehabilitated, and that most of the waste rock will go back into the pit with the remnant remains being rehabilitated:

- New hydropedology flow regimes will form as a result of the backfilled opencast pit. Backfill material properties will not be similar to the in-situ soil properties, and will likely promote interflow from the pit into the surrounding areas.
- The soil at the power yard, processing plant and crusher area will likely be compacted, even after the structures are removed. Hence, post-closure hydropedological flow in these may be subjected to overland flow and less interflow.
- Waste rock not used for the pit backfilling activities will likely be retained within the conceptual laydown area. Unrehabilitated and rehabilitated waste rock dumps will likely induce greater runoff into the surrounding areas, rather than promote pre-mining interflow. This may lead to the sedimentation of nearby watercourses.

4.4 Cumulative impacts

As activities will take place in the same drainage areas, and entail mining and other supporting activities (i.e. processing, and mine residue waste storage etc.) there will be cumulative impacts. The operational phase risk table includes cumulative risk about the site, and activities thereon.

The potential impact on hydropedological flow drivers and risk associated with the activities mentioned above were further investigated in the sub-sections below.

Table 4-4: Estimated hydropedological risks (Preparation Phase)

COMPONENT BEING IMPACTED ON	ACTIVITY THAT MAY CAUSE THE IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
Soil interflow processes: • Alteration to natural hydropedological flow paths by infilling or cut and fill activities. • Impacts on the macro-soil structure. • Impacts on the hydropedological processes supporting the watercourses.	**Crusher, processing plant, access roads, pipeline, WRD and opencast operations** Site preparation, including placement of contractor laydown areas and storage (i.e. temporary stockpiles, bunded areas etc.) facilities.	Earthworks	4	2	1	6	42	-	M	Only excavate areas applicable to the project area. Cover excavated soils with a temporary liner to prevent contamination. Keep the site clean of all general and domestic wastes. All mine and laydown footprint areas are to remain as small as possible and vegetation clearing is to be limited to what is essential. Retain as much indigenous vegetation as possible. Exposed soils are to be protected using a suitable covering or revegetated. Existing roads should be used as far as practical to gain access to the site. Have emergency fuel & oil spill kits on site. Soil quality monitoring (monthly monitoring proposed during the installation of fuel storage tanks) & visual assessments during the construction phase proposed. Visual assessment of the sites should be taken at least once a week during construction etc by the ECO	2	1	1	3	12	-	L-Marginal
Soil structure & land capability: • Exposure of soils, leading to increased runoff from cleared areas and erosion of the watercourses, thus increasing the potential for sedimentation of the watercourses. • Vegetation loss. • Soil compaction; and • Soil erosion.	**Crusher, processing plant, access roads, pipeline, WRD and opencast operations** Disturbing vadose zone during soil excavations / infilling activities.	Earthworks	4	2	1	6	42	-	M		2	2	1	3	15	-	L
Soil quality: • Natural nutrient content decreases due to soil exposure. • Loss of natural bio-organisms essential to soil processes.	**Crusher, processing plant, access roads, pipeline, WRD and opencast operations** Vegetation clearing & soil stockpiling.	Earthworks	4	2	1	6	42	-	M		2	2	1	3	15	-	L
Surface water (perennial & non-perennial streams and wetlands)	**Crusher, processing plant, access roads, pipeline, WRD and opencast operations** Leakages from vehicles and machines. Surface water contamination and sedimentation from the following activities: • Erosion and sedimentation of watercourses if excavations are left open due to unforeseen circumstances (i.e. bad weather); and • Alteration of natural drainage lines which may lead to ponding or increased runoff patterns (i.e. may cause stagnant water levels or increase erosion).	Mechanised machinery & seepage/runoff from building materials.	2	1	1	5	20	-	L	Visual soil assessment for signs of contamination at vehicle holding, parking and activity areas. Place oil drip trays under parked construction vehicles and hydraulic equipment at the site. Exposed soils are to be protected using a suitable covering or revegetated. Have emergency fuel & oil spill kits on site. Surface water monitoring (monthly water monitoring proposed of critical watercourses downstream of construction areas)	0	1	1	2	4	-	L - Marginal

COMPONENT BEING IMPACTED ON	ACTIVITY THAT MAY CAUSE THE IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
Shallow groundwater occurrences: • Perched Water Table Dewatering / Rainwater collected in cut-and-fill areas.	**Crusher, processing plant, access roads, pipeline, WRD and opencast operations** In areas where shallow groundwater / perched groundwater occurs (likely associated with responsive shallow and saturated soil types), dewatering activities (i.e. for placing of platforms etc.) may impact natural soil-flow processes.	Earthworks	2	2	1	4	20	-	L	Ensure all dewatered groundwater is discharged to the closest drainage line; or back to the downstream environment via artificial discharge points (i.e. swales or attenuation ponds)	0	1	1	1	2	-	L - Marginal

Table 4-5: Estimated hydropedological risks (Operational / Mining Phase)

COMPONENT BEING IMPACTED ON	ACTIVITY THAT MAY CAUSE THE IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
Soil interflow processes: • Infilling of wetlands and watercourses inducing alternative flow paths. • Alteration to natural hydropedological flow paths. • Impacts on the macro-soil structure. • Impacts on the hydropedological processes supporting the watercourses.	**Placing the WRD and other stockpiles** Dumping waste rock on top of soils and in or near watercourses will likely have an impact on the soil flow dynamics. For wetland areas identified by Eco-Pulse (2021), infilling may change flow volumes (as the material will likely become dry over time) and new predominant soil flow processes will form (i.e. form responsive to interflow type). Similarly, if the waste rock is placed upstream of identified wetlands there may be more runoff into the wetlands, altering the natural flow system. Watercourses in the area (mainly perennial streams as non-perennial streams in this area tend to be ephemeral) may be subjected to receive less interflow, or more interflow, depending on the position of the placement of the waste rock (i.e. infilling of drainage line will cause suppress natural interflow, as opposed to upstream which could promote interflow but likely increase runoff).	The net result of earthworks & mining activities.	4	3	1	4	32	-	M	Placing a suitable geotextile in areas near or on top of watercourses/wetlands, before placement of the soils, may help maintain some sub-surface soil processes. Compact and revegetate eroded areas. Establish where the waste rock will be placed, and if the area is suitable to receive the excavated material.	2	2	2	4	24	-	L
	Opencast Pit Expansion Shallow lateral water seepage and percolation are associated with the opencast operation. The mining will entail strip mining (*the depths of the pit is uncertain as the designs are conceptual*), and it is anticipated that limited removal of deep lateral water seepage may occur (i.e. the cone of depression will be limited to the maximum depth of the mine works).	The net result of earthworks & mining activities	4	3	1	4	32	-	M	No mitigation is possible. This is a net result of the pit expansion.	4	3	1	4	32	-	M

COMPONENT BEING IMPACTED ON	ACTIVITY THAT MAY CAUSE THE IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
	<u>Soil water interception at the WRD, Crusher, Process Plant and Opencast</u> Surface water interception and reduced rainfall runoff to watercourses and drainage servitudes (i.e. this water will be captured by the WRD, crusher process plant and power yard stormwater systems or opencast workings). Natural groundwater recharge may also be reduced.	The net result of earthworks & mining activities.	4	3	1	4	32	-	M	Ensure all captured interflow water (i.e. water flowing into the opencast pit) and water captured by the stormwater systems of all facilities is discharged to the closest drainage line; or back to the downstream environment via artificial discharge points (i.e. swales or attenuation ponds)	2	3	1	4	24	-	L
<u>Soil structure & land capability:</u> • Exposure of soils, leading to increased runoff from cleared areas and erosion of the watercourses, thus increasing the potential for sedimentation of the watercourses. • Vegetation loss. • Soil compaction; and • Soil erosion.	**<u>Crusher, processing plant, access roads, WRD and opencast operations.</u>** Areas that were backfilled with collapsible soils; or steep pit slopes may cause soil subsidence/ hanging wall erosion. Soil structure may be compromised.	The net result of earthworks & mining activities.	4	3	1	4	32	-	M	Ensure pit slopes are kept as per best practice guidelines, to reduce wind erosion and compromise the slope stability. Optimise pit expansion by employing rollover methods as a mining protocol. Only excavate areas applicable to the project area. Retain as much indigenous vegetation as possible during the ongoing activities; or re-vegetate areas prone to cause erosion. Ensure stockpiles are kept at optimum levels and within the process facility footprint. Cover stockpiles with a temporary liner to prevent contamination. Keep all areas clean of all general and domestic wastes. All mine and laydown footprint areas are to remain as small as possible and vegetation clearing is to be limited to what is essential.	4	3	1	3	24	-	L
	<u>Crusher, processing plant, access roads, WRD and opencast operations</u> Soils placed on temporary stockpiles may be prone to cause erosion and sedimented runoff if high precipitation occurs in the area. It may take some time for these areas to stabilise (i.e. to establish new soil flow dynamics). Soils in contact with the new watercourse will become saturated, and with time may change the soil morphology.	The net result of earthworks & mining activities.	4	3	1	3	24	-	L		4	3	1	3	24	-	L

COMPONENT BEING IMPACTED ON	ACTIVITY THAT MAY CAUSE THE IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
Soil quality	**Crusher, processing plant, access roads, WRD and opencast operations** Soils/mining material placed near watercourses may be prone to erosion and sedimented runoff if high precipitation occurs in the area. It may take some time for these areas to stabilise (i.e. to establish new interflow soil dynamics). There may also be secondary seepage from these mine materials/soils which could impact soil-water quality. Seepage/leakages/overland flow from oil & fuel spills from vehicles parked and operating at the mine may compromise soil quality. Prolonged pollution may migrate to the nearby watercourse and/or percolate into the groundwater table.	The net result of mining.	4	3	1	3	24	-	L	Visual soil assessment for signs of contamination at vehicle holding, parking and activity areas. Place oil drip trays under parked construction vehicles and hydraulic equipment at the site. Exposed soils are to be protected using a suitable covering or revegetated. Have emergency fuel & oil spill kits on site.	4	3	1	2	16	-	L
Shallow groundwater occurrences: • Perched Water Table Dewatering / Rainwater collected in cut-and-fill areas.	**Crusher, processing plant, access roads, WRD and opencast operations** Decreased rainfall infiltration will decrease groundwater contribution to baseflow (i.e. baseflow to gaining wetland systems).	The net result of earthworks & mining activities.	4	3	1	3	24	-	L	Discharging stormwater into the receiving environment is recommended. Releasing enough water during rainfall events, and gradually after rainfall events (i.e. captured stormwater) will help to stabilise interflow to lower topographical areas. Irrigation of open spaces at the site may help to maintain the hydropedological function of soils and the functionality of wetlands in the area.	4	3	1	2	16	-	L - Marginal
Surface water quality	**Crusher, processing plant, access roads, WRD and opencast operations** Poor-quality stormwater discharge and poor-quality seepage & runoff from vehicles parked at the mine may impact primary surface water receivers. Increased runoff from the process plant, crusher, power yard and WRD could impact surface water quality in nearby watercourses and may further change hydropedological functions of the soils associated with the watercourses (i.e. may promote hydromorphic changes after long exposure periods [> 1 to 2 years]).	The net result of earthworks & mining activities.	4	3	1	2	16	-	L	Park vehicles in designated areas. Place oil drip trays under parked vehicles and hydraulic equipment at the site. Surface water monitoring.	2	3	1	2	12	-	L - Marginal

Table 4-6: Estimated hydropedological risks (Closure Phase)

COMPONENT BEING IMPACTED ON	ACTIVITY THAT MAY CAUSE THE IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
Soil interflow processes: • Alteration to natural hydropedological flow paths by infilling or cut and fill activities. • Impacts on the macro-soil structure. • Impacts on the hydropedological processes supporting the watercourses. Soil structure & land capability: • Exposure of soils, leading to increased runoff from cleared areas and erosion of the watercourses, thus increasing the potential for sedimentation of the watercourses. • Vegetation loss. • Soil compaction; and • Soil erosion. Soil quality: • Natural nutrient content decreases due to soil exposure. • Loss of natural bio-organisms essential to soil processes.	**Crusher, processing plant, access roads, WRD and opencast operations** Site decommissioning and removal of infrastructure. The soil at the power yard, processing plant and crusher area will likely be compacted, even after the structures are removed. Hence, post-closure hydropedological flow in these may be subjected to overland flow and less interflow.	Earthworks and rehabilitation activities	4	2	1	6	42	-	M	Only excavate areas applicable to the project area. Cover excavated soils with a temporary liner to prevent contamination. Keep the site clean of all general and domestic wastes. All mine and laydown footprint areas are to remain as small as possible and vegetation clearing is to be limited to what is essential. Retain as much indigenous vegetation as possible. Exposed soils are to be protected using a suitable covering or revegetated. Existing roads should be used as far as practical to gain access to the site. Have emergency fuel & oil spill kits on site. Soil quality monitoring (monthly monitoring proposed during the installation of fuel storage tanks) & visual assessments during the construction phase proposed.	2	1	1	3	12	-	L- Marginal
	Crusher, processing plant, access roads, WRD and opencast operations Disturbing vadose zone during rehabilitation activities	Earthworks and rehabilitation activities	4	2	1	6	42	-	M		2	2	1	3	15	-	L
	Crusher, processing plant, access roads, WRD and opencast operations Re-vegetating of eroded areas as part of the rehabilitation of all areas.	Earthworks and rehabilitation activities	4	2	1	6	42	-	M		2	2	1	3	15	-	L
	Rehabilitated opencast New hydropedology flow regimes will form as a result of the backfilled opencast pit. Backfill material properties will not be similar to the in-situ soil properties, and will likely promote interflow from the pit into the surrounding areas.	Earthworks and rehabilitation activities	4	3	1	3	24	+	L	No mitigation is required. Positive effects.	4	3	1	3	24	+	L
Surface water (perennial & non-perennial streams and wetlands)	**Crusher, processing plant, access roads, WRD and opencast operations** Waste rock not used for the pit backfilling activities will likely be retained within the conceptual laydown area. unrehabilitated and rehabilitated waste rock dumps will likely induce greater runoff into the surrounding areas, rather than promote pre-mining interflow. This may lead to the sedimentation of nearby watercourses. Leakages from vehicles and machines used during the rehab process.	Earthworks and rehabilitation activities	2	1	1	5	20	-	L	Visual soil assessment for signs of contamination at vehicle holding, parking and activity areas. Place oil drip trays under parked construction vehicles and hydraulic equipment at the site. Exposed soils are to be protected using a suitable covering or revegetated. Have emergency fuel & oil spill kits on site. Surface water monitoring (monthly water monitoring proposed of critical watercourses downstream of construction areas)	0	1	1	2	4	-	L - Marginal

5 PROPOSED SOIL MONITORING

The proposed soil and hydrogeological monitoring program are based on the principles of a monitoring network design as described by the DWAF Best Practice Guidelines: G3 Monitoring (DWAF, 2007). The methodological approach that the monitoring plan follows is represented in Figure 5-1, below.

Figure 5-1: Monitoring Process

5.1 Establishment of the monitoring network

Currently, no soil monitoring is taking place. It is proposed that a proper monitoring programme be implemented to monitor both the soil quality and the potential impact on the hydropedological flow drivers. This process typically entails two (2) types:

- Type 1: Monitoring during preparation activities; and
- Type 2: Permanent monitoring during the mining and post-mining phases of the project (i.e. in areas about the proposed WRD, processing complex and opencast pit).

5.1.1 Type 1 monitoring

It is proposed that during the preparation phase of the project, soil monitoring focuses on contractor laydown areas, initial excavation sites and equipment / heavy machinery parking. Regular visual inspections of these areas need to be undertaken. Visual assessment of the sites should be taken at least once a week during construction and site preparation by the appointed ECO. Moreover, placement and monitoring of drip trays underneath parked construction vehicles will help to determine which vehicles need to be repaired/taken off-site to prevent contamination while in service.

5.1.2 Type 2 monitoring

Type 2 monitoring would maintain the protocols as stated in Type 1, with the inclusion of routine random soil sampling downstream and upstream of the WRD, opencast pit, processing complex, stockyards etc. Bi-annual sampling is proposed, and sampling areas after inspection of the ECO (with observable issues) are recommended to take place immediately. Soil sample analyses should include (pH, EC, TDS, Ca, Mg, Na, K, Cl, F, NO_3, SO_4, Fe, Al, Zn, Mn, Pb and Cr(III), particle size distribution to estimate soil permeabilities and changes thereof).

It is further proposed that shallow soil piezometers be installed, with soil moisture tensiometers installed, specifically in areas downstream of the proposed WRD and opencast pit. The aim would be to gather long-term soil moisture data and to determine the impact of the opencast pit expansion and suppression on flow drivers as a result of the placement of the WRD on the watercourses downstream of the mentioned infrastructure. This can only be determined by monitoring, and developing hydropedological and geohydrological models once the data is available for calibration of the suggested modelling platforms. The models can be used to track, predict and manage future hydropedological impacts. Positions of the tensiometers can only be determined once pit layouts are finalised.

6 CONCLUSIONS

Generally, recharge soils are dominant across the project area. These soils do not have any morphological indication of saturation.

- Vertical flow through and out of the profile into the underlying bedrock is the dominant flow path. These soils are deep and freely drained and are experiencing the leaching of nutrients to underlying soil horizons.

Moving towards the crest/hilltops on the hillslopes associated with the project area are generally responsive (soil/bedrock) soils (Mispah, Glenrosa, Avalon and Mancini soil forms).

- Shallow hard rock or soft plinthic B horizons will signify a temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction will occur. In areas where bedrock has been subjected to fracturing secondary flow paths towards the groundwater table could exist. Water in the fractured zone will likely seep vertically down into the groundwater table.

The area associated with the valley bottom is associated with hydrogeomorphic soil types (such as the Katspruit soil form) and will primarily be responsive (saturated) or responsive (shallow) – depending on the degree of saturation.

- In responsive soils, the build-up of water is expected in the B and upper A horizons after rain and overland discharge and minor lateral seepage as expected (due to saturation excess). Secondary vertical seepage to deeper soil zones from the saturated B horizon is expected. At the transition from one soil type to the other (upstream to downstream) overland flow may take place during wet seasons. The release of water from the gleyic horizons will be somewhat slow and can still contribute to vertical and lateral water movement during dry periods. A shallow vertical movement to sub-soils is expected.

Several hydropedological risks were identified for the preparation, operational and closure phases of the project (refer to Section 4). Based on the conceptual mine layout plans provided, the HSTs and sub-catchments delineated for the primary mining area, the following impacts are anticipated (in terms of suppressing the natural hydropedological flow drivers):

- As most of the mining will take place in HRU1, the predicted impact on the PES / EIS for watercourses associated with this HRU is “Moderate”. This is largely due to the size of the conceptual layouts provided for this assessment, and the net results of all the activities taking place in one sub-catchment. If the mine footprints are reduced, the impact on PES / EIS should decrease.
- The predicted impact for HRU2 and HRU3 is “No impact” and “Low” (respectively), as only a small portion of the SE Pit falls in these sub-catchments.

6.1 Recommendations and Mitigation measures for inclusion in the EMPr

The following recommendations are made:

- Ensure clean stormwater is conveyed to the natural environment. An attenuation pond can be used to ensure steady seepage of accumulated stormwater into the soils upstream of wetland areas.
- Ensure fuel spill cleaning kits are on standby to mitigate any fuel/oil leakages which could compromise soil quality.
- Ensure that all mine infrastructure footprints are as small as possible, to prevent suppression of hydropedological flow drivers. Moreover, the WRD footprint provided is very large (>450 Ha) and it is recommended that the footprint is reduced in the final mine layout plan.
- It is recommended that a follow-up hydropedology assessment be undertaken when more detailed mine plans and designs are available. This assessment followed a worst-case scenario approach where the focus was on higher-risk areas; and areas where conceptual drawings are available.
- It is recommended that wetland buffers delineated by a wetland specialist be incorporated into the final designs of the mine. These buffer areas should also be sufficient to further promote natural hydropedological functions.
- Due to the limited number of samples collected, the soil permeability estimates are considered preliminary. More samples should be taken before mining and the establishment of the surface infrastructure, to confirm soil permeability and potential impacts on the hydrological drivers relating to soil texture.
- Implement soil and hydropedological monitoring as per Section 5 of this report.
- It is recommended that positions for the installation of soil tensiometer piezometers be determined once the pit and WRD layouts have been finalised.
    - The aim would be to gather long-term soil moisture data and to determine the impact of the opencast pit expansion and suppression on flow drivers as a result of the placement of the WRD on the watercourses downstream of the mentioned infrastructure.
    - This can only be determined by monitoring, and developing hydropedological and geohydrological models once the data is available for calibration of the suggested modelling platforms. The models can be used to track, predict and manage future hydropedological impacts.
    - Positions of the tensiometers can only be determined once pit layouts are finalised.

- It is recommended that mitigation measures, as described in Section 4 be implemented during the construction and operational phase of this project.

6.2 Avoidance areas

No hydropedological avoidance areas have been identified and will be difficult to implement considering the potential impact areas associated with the project.

6.3 Reasoned opinion on whether the activity should be authorized

After consideration of the risks identified, and the proposed mitigation measures to offset the likely impacts, no concrete reason not to continue with the project has been identified. Avoiding encroachment of wetlands should be considered during all activities relating to the project, and it is proposed that the risk identified in this report be updated once final designs for the infrastructure for this project is available. The recommendations below and in the risk impact table should be considered for incorporation into the EIA and IWWMP. Moreover, wetland buffers as determined by EcoPulse (2021) should be sufficient to sustain the hydropedological functions of wetland units and watercourses in the project area.

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APPENDIX A: RISK ASSESSMENT

Each impact identified (for the commissioning, operational and decommissioning phases) was assessed in terms of probability (likelihood of occurring), scale (spatial scale), magnitude (severity) and duration (temporal scale). To enable a scientific approach to the determination of the environmental significance (importance), a numerical value is linked to each rating scale.

The following criteria were applied:

- **<u>Occurrence:</u>**
    - Probability of occurrence (how likely is it that the impact may occur?); and
    - Duration of occurrence (how long the impact may last).
- **<u>Severity:</u>**
    - Magnitude (severity) of impact (will the impact be of high, moderate, or low severity?); and
    - Scale/extent of impact (will the impact affect the national, regional, or local environment or only that of the site?).

The impact assessment rankings used are listed in Table 1. The significance of the impact was determined by the formula below and was screened according to Table 2.

SP (significance of impact) = (magnitude + duration + scale) x probability

Table 1: Impact assessment rankings

Status of Impact	
+: Positive (A benefit to the receiving environment)	
N: Neutral (No cost or benefit to the receiving environment)	
-: Negative (A cost to the receiving environment)	
Magnitude: =M	**Duration: =D**
10: Very high/do not know	5: Permanent
8: High	4: Long-term (ceases with the operational life)
6: Moderate	3: Medium-term (5-15 years)
4: Low	2: Short-term (0-5 years)
2: Minor	1: Immediate
0: Not applicable/none/negligible	0: Not applicable/none/negligible
Scale: =S	**Probability: =P**
5: International	5: Definite/do not know

4: National	4: Highly probable
3: Regional	3: Medium Probability
2: Local	2: Low probability
1: Site only	1: Improbable
0: Not applicable/none/negligible	0: Not applicable/none/negligible

Table 2: Impact significance ratings

Significance	Environmental Significance Points	Colour Code
High (positive)	>60	H
Medium (positive)	30 to 60	M
Low (positive)	15 to 30	L
Low-Marginal (positive)	0 to 15	L-Marginal
Neutral	0	N
Low-Marginal (Negative)	0 to -15	L-Marginal
Low (negative)	-15 to -30	L
Medium (negative)	-30 to -60	M
High (negative)	<-60	H

APPENDIX B: FIELD DATA

Waste dump/overburden

Auger hole logging data sheet			
Hole ID:	WA1	Latitude	-28.709062
Project:	Jindal Mine Hydroped	longitude	31.478249
Project No:	20-1221	Elevation (m amsl)	402.92
Province	KZN	Depth (m)	3
Logged by	Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size	
0	0.41	Orthic A: Moist; Black; Friable; Granular; Loam; Fine grained soil	
0.41	1.56	Yellow Brown Apedal B: Moist; Yellow brown; Loose; Granular; Sandy loam, fine grained soil	
1.56	3	Saprolite/Unspecified B: Moist; Yellow Brown; Very Friable; Granular; Sandy; fine grained sandy; Residual soil	
Comment		Soil grades into weathered granite	
Soil form		Clovelly	

Auger hole logging data sheet			
Hole ID:	WA2	Latitude	-28.708201
Project:	Jindal Mine Hydroped	longitude	31.478486
Project No:	20-1221	Elevation (m amsl)	404.34
Province	KZN	Depth (m)	2.3
Logged by	Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size	
0	0.32	Orthic A: Moist; Black; Friable; Granular; Loam; Fine grained soil	
0.32	0.85	Yellow Brown Apedal B: Moist; Yellow brown; Loose; Granular; Sandy loam, fine grained soil	
0.85	2.3	Saprolite/Unspecified B: Moist; Yellow Brown; Very Friable; Granular; Sandy; fine grained sandy; Residual soil	
Comment		refusal	
Soil form		Clovelly	

Auger hole logging data sheet			
Hole ID:	WA4	Latitude	-28.706412
Project:	Jindal Mine Hydroped	longitude	31.475691
Project No:	20-1221	Elevation (m amsl)	425
Province	KZN	Depth (m)	1.52
Logged by	Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size	
0	0.42	Orthic A: Moist; Brown; Friable; Granular; Loam; Fine grained soil	
0.42	1.52	Lithocunatic B: Moist; light brown; very Friable; Granular; Sandy loam, fine grained soil with lithic fragments	
Soil form		Glenrosa	

Auger hole logging data sheet				
Hole ID:		WA5	Latitude	-28.705533
Project:		Jindal Mine Hydroped	longitude	31.474719
Project No:		20-1221	Elevation (m amsl)	444.08
Province		KZN	Depth (m)	0.68
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.68	Orthic A: Dry; Grey; loose; Granular; Loam; Fine grained soil with lithic fragments		
Soil form		Mispah		

Auger hole logging data sheet				
Hole ID:		WA6	Latitude	-28.704273
Project:		Jindal Mine Hydroped	longitude	31.474816
Project No:		20-1221	Elevation (m amsl)	455.29
Province		KZN	Depth (m)	1.1
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.3	Orthic A: Moist; Brown; Friable; Granular; Loam; Fine grained soil		
0.3	1.1	Lithocunatic B: Moist; light brown; loose; Granular; Sandy loam, fine grained soil with lithic fragments		
Soil form		Glenrosa		

Auger hole logging data sheet				
Hole ID:		WA7	Latitude	-28.703309
Project:		Jindal Mine Hydroped	longitude	31.476594
Project No:		20-1221	Elevation (m amsl)	467.85
Province		KZN	Depth (m)	1.76
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.42	Orthic A: Moist; Black; Friable; Granular; Loam; Fine grained soil		
0.42	1.76	Lithocunatic B: Moist; light brown; Stiff; Subangular- Granular; sandy loam, fine grained; Residual soil with lithic fragments		
Soil form		Glenrosa		

Auger hole logging data sheet				
Hole ID:		WA8	Latitude	-28.704342
Project:		Jindal Mine Hydroped	longitude	31.47781
Project No:		20-1221	Elevation (m amsl)	466.5
Province		KZN	Depth (m)	0.9
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.35	Orthic A: Dry; Black; Friable; Granular; Loam; Fine grained soil		
0.35	0.9	Lithocunatic B: Dry; Brown; Hard ; Granular; sandy loam, fine grained; Residual soil with lithic fragments		
Soil form		Glenrosa		

Auger hole logging data sheet				
Hole ID:		WA9	Latitude	-28.699556
Project:		Jindal Mine Hydroped	longitude	31.458463
Project No:		20-1221	Elevation (m amsl)	586
Province		KZN	Depth (m)	2.54
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.22	Orthic A: Moist; Black; Friable; Granular; Loam; Fine grained soil		
0.22	1.45	Yellow Brown Apedal B: Moist; reddsih brown; very Friable; Blocky; Sandy loam, fine grained soil		
1.5	2.54	Unspecified B: Moist; Yellow Brown; Very Friable; Granular; Sandy; fine grained sandy; Residual soil		
Soil form		Clovelly		

Auger hole logging data sheet				
Hole ID:		WA10	Latitude	-28.699656
Project:		Jindal Mine Hydroped	longitude	31.461468
Project No:		20-1221	Elevation (m amsl)	553.48
Province		KZN	Depth (m)	2.65
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.1	Orthic A: Moist; Reddish Brown; Friable; Granular; Loam; Fine grained soil		
0.1	1.57	Yellow Brown Apedal B: Moist; Reddish brown; very Friable; Granular; Loamy, fine grained soil		
1.57	2.65	Soft Plinthic B: Moist; Yellow Brown; Very Friable; Granular; Sandy; fine grained sandy; Residual soil		
Soil form		Avalon		

Auger hole logging data sheet				
Hole ID:		WA11	Latitude	-28.700534
Project:		Jindal Mine Hydroped	longitude	31.460438
Project No:		20-1221	Elevation (m amsl)	567.79
Province		KZN	Depth (m)	0.62
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.12	Orthic A: Dry; Black; Friable; Granular; Loam; Fine grained soil		
0.12	0.62	Lithocunatic B: Dry; Brown; Hard ; Granular; Sandy loam, fine grained; Residual soil with lithic fragments		
Soil form		Glenrosa		

Auger hole logging data sheet				
Hole ID:		WA12	Latitude	-28.700631
Project:		Jindal Mine Hydroped	longitude	31.456785
Project No:		20-1221	Elevation (m amsl)	609.57
Province		KZN	Depth (m)	3
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.22	Orthic A: Moist; Black; Friable; Granular; Loam; Fine grained soil		
0.22	1.45	Yellow Brown Apedal B: Moist; reddsih brown; very Friable; Blocky; Sandy loam, fine grained soil		
1.45	3	Unspecified B: Moist; Yellow Brown; Very Friable; Granular; Sandy; fine grained sandy; Residual soil		
Soil form		Clovelly		

Auger hole logging data sheet				
Hole ID:		WA13	Latitude	-28.702708
Project:		Jindal Mine Hydroped	longitude	31.456549
Project No:		20-1221	Elevation (m amsl)	581.3
Province		KZN	Depth (m)	2.71
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.38	Orthic A: Moist; Brown; Friable; Granular; Loam; Fine grained soil		
0.38	1.88	Yellow Brown Apedal B: Moist; reddsih brown; Very Friable; granular; Sandy loam, fine grained soil		
1.88	2.71	Unspecified B/Saprolite: Moist; Pinkish White; Very Loose; Granular; Sandy; Fine grained; Residual soil		
Soil form		Clovelly		

Auger hole logging data sheet				
Hole ID:		WA14	Latitude	-28.703287
Project:		Jindal Mine Hydroped	longitude	31.455597
Project No:		20-1221	Elevation (m amsl)	584.5
Province		KZN	Depth (m)	2.5
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.22	Orthic A: Moist; Dark Brown; Friable; Granular-Blocky; Fine; Loamy soil		
0.22	2.5	Red Apedal B: Moist; Red; Very Friable; Granular; fine to medium grained; loamy soil.		
Soil form		Hutton		

Auger hole logging data sheet				
Hole ID:		WA15	Latitude	-28.703501
Project:		Jindal Mine Hydroped	longitude	31.453949
Project No:		20-1221	Elevation (m amsl)	570.25
Province		KZN	Depth (m)	0.95
Logged by		Siphe	Water level (mbgl)	0.25
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.35	Orthic A: Moist; Dark Grey; Friable; Granular; Fine; Loamy soil		
0.35	0.95	G Horizon: Wet; Dark grey to Back; Firm; Blocky; Clayey loam soil		
Soil form		Katspruit		

Auger hole logging data sheet				
Hole ID:		WA16	Latitude	-28.704287
Project:		Jindal Mine Hydroped	longitude	31.453684
Project No:		20-1221	Elevation (m amsl)	567.5
Province		KZN	Depth (m)	3
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.42	Orthic A: Moist; Grey; Friable; Granular; Loam; Fine grained soil		
0.42	2.53	Yellow Brown Apedal B: Moist; reddsih brown; Friable; granula; loam; fine grained soil		
2.53	3	Unspecified B/Saprolite: Moist; light grey; Very Loose; Granular; Sandy; Fine grained; Residual soil		
Soil form		Clovelly		

Auger hole logging data sheet					
	Hole ID:		WA17	Latitude	-28.704919
	Project:		Jindal Mine Hydroped	longitude	31.45295
	Project No:		20-1221	Elevation (m amsl)	559.2
	Province		KZN	Depth (m)	1.25
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.25	Orthic A: Dry; Black; Friable; Granular; Loam; Fine grained soil		
	0.25	1.25	Lithocunatic B: Dry; Brown; Hard; Granular; Sandy loam, fine grained; Residual soil with lithic fragments		
	Soil form		Glenrosa		

Auger hole logging data sheet					
	Hole ID:		WA18	Latitude	-28.705971
	Project:		Jindal Mine Hydroped	longitude	31.451387
	Project No:		20-1221	Elevation (m amsl)	520.15
	Province		KZN	Depth (m)	0.31
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.31	Orthic A: Dry; Brown; Hard; Granular; Sandy loam, fine grained; Residual soil with lithic fragments		
		0.31	Hard Rock		
	Comment		Granite outcrops clearly visible around this point		
	Soil form		Mispah		

Auger hole logging data sheet					
	Hole ID:		WA21	Latitude	-28.70449
	Project:		Jindal Mine Hydroped	longitude	31.456646
	Project No:		20-1221	Elevation (m amsl)	595.86
	Province		KZN	Depth (m)	0.65
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.18	Orthic A: Dry; Black; Friable; Granular; Loam; Fine grained soil		
	0.18	0.65	Lithocunatic B: Dry; Brown; Hard; Granular; Sandy; medium grained; Residual soil with lithic fragments		
	Soil form		Glenrosa		

Auger hole logging data sheet			
Hole ID:	WA22	Latitude	-28.705243
Project:	Jindal Mine Hydroped	longitude	31.458193
Project No:	20-1221	Elevation (m amsl)	585.32
Province	KZN	Depth (m)	1.26
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.15	Orthic A: Dry; Brown; Soft; Granular; Loam; Fine grained soil
0.15	0.88	Yellow Brown Apedal B: Moist; reddsih brown; Friable; granular; loam; fine grained soil
0.88	1.26	Unspecified B/Saprolite: Moist; light grey; Very Loose; Granular; Clayey loam; Fine grained; Residual soil
		refusal
Soil form		Clovelly

Incoming power yard

Auger hole logging data sheet			
Hole ID:	IA1	Latitude	-28.706216
Project:	Jindal Mine Hydroped	longitude	31.442487
Project No:	20-1221	Elevation (m amsl)	654.84
Province	KZN	Depth (m)	1.05
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.3	Orthic A: Moist; Black; Loose; Granular; Loam; Medium grained soil
0.3	1.05	Lithocunatic B: Dry; Reddish Brown; Hard; Granular; Sandy; Fine grained; Residual soil with lithic fragments
		Refusal
Soil form		Glenrosa

Auger hole logging data sheet			
Hole ID:	IA2	Latitude	-28.706067
Project:	Jindal Mine Hydroped	longitude	31.443006
Project No:	20-1221	Elevation (m amsl)	650.32
Province	KZN	Depth (m)	3
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.17	Orthic A: Moist; Dark Brown; Friable; Granular-Blocky; Fine; Loamy soil
0.17	2.57	Red Apedal B: Moist; Red; Friable; Granular; fine to medium grained; loamy soil.
2.57	3	Unspecified B: Moist; Red; Very Friable; Granular; fine to medium grained; loamy soil.
Soil form		Hutton

Auger hole logging data sheet

Hole ID:	IA3	Latitude	-28.705767
Project:	Jindal Mine Hydroped	longitude	31.443868
Project No:	20-1221	Elevation (m amsl)	643.19
Province	KZN	Depth (m)	3
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.25	Orthic A: Moist; Dark Brown; Friable; Granular-Blocky; Fine; Loamy soil
0.25	1.2	Red Apedal B: Moist; Red; Friable; Granular; fine to medium grained; loamy soil.
1.2	3	Unspecified B: Moist; Pinkish White; loose; Granular; fine grained; Sandy soil. Signs of highly weathered granite
Soil form		Hutton

Auger hole logging data sheet

Hole ID:	IA6	Latitude	-28.705075
Project:	Jindal Mine Hydroped	longitude	31.443615
Project No:	20-1221	Elevation (m amsl)	637.63
Province	KZN	Depth (m)	3
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.41	Orthic A: Moist; Dark Brown; Friable; Granular-Blocky; Fine; Loamy soil
0.41	2.56	Red Apedal B: Moist; Red; Friable; Granular; fine to medium grained; Loamy soil.
2.56	3	Unspecified B: Moist; Weak Yellow; Loose; Granular; Fine grained; Sandy; Residual soil. Signs of highly weathered granite
Soil form		Hutton

Auger hole logging data sheet

Hole ID:	IA7	Latitude	-28.704987
Project:	Jindal Mine Hydroped	longitude	31.442958
Project No:	20-1221	Elevation (m amsl)	643.95
Province	KZN	Depth (m)	3
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.25	Orthic A1: Moist; Dark Brown; Friable; Granular-Blocky; Fine; Loamy soil
0.25	0.82	Orthic A2: Moist; Reddish Brown; Firm; Blocky; Fine; Loamy soil
2.56	3	Red Apedal B: Moist; Red; Friable; Granular; fine to medium grained; Loamy soil.
Soil form		Hutton

Auger hole logging data sheet					
	Hole ID:		IA8	Latitude	-28.704812
	Project:		Jindal Mine Hydroped	longitude	31.44246
	Project No:		20-1221	Elevation (m amsl)	647.63
	Province		KZN	Depth (m)	3
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.18	Orthic A: Moist; Dark Brown; Friable; Blocky; Fine grained; loam soil		
	0.18	1.4	Yellow Brown Apedal B: Moist; Yellowish Brown; Friable; Granular to Blocky; Medium grained; Loam soil		
	1.4	3	Unspecified B: Moist; Yellow Brown; Friable; Granular; Fine grained; Residual; Loam soil.		
	Soil form		Clovelly		

Auger hole logging data sheet					
	Hole ID:			Latitude	-28.704522
	Project:		Jindal Mine Hydroped	longitude	31.443076
	Project No:		20-1221	Elevation (m amsl)	637.18
	Province		KZN	Depth (m)	3
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.35	Orthic A: Moist; Dark Brown; Friable; Granular-Blocky; Fine; Loamy soil		
	0.35	2.2	Red Apedal B: Moist; Red; Friable; Granular; fine to medium grained; Loamy soil.		
	2.2	3	Unspecified B: Moist; Weak Yellow; Loose; Granular; Fine grained; Sandy; Residual soil. Signs of highly weathered granite (K-Feldspar & Mica)		
	Soil form		Hutton		

Primary crusher

Auger hole logging data sheet				
Hole ID:		CA2	Latitude	-28.715458
Project:		Jindal Mine Hydroped	longitude	31.45482
Project No:		20-1221	Elevation (m amsl)	563.5
Province		KZN	Depth (m)	1.72
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.15	Orthic A: Dry; Browinsh Yellow; loose Granular; Loam; Medium grained soil		
0.15	1.72	Lithocunatic B: Dry; Brownish Yellow; Hard; Granular; Sandy; medium grained; Residual soil with lithic fragments		
Soil form		Glenrosa		

Auger hole logging data sheet				
Hole ID:		CA3	Latitude	-28.715478
Project:		Jindal Mine Hydroped	longitude	31.455599
Project No:		20-1221	Elevation (m amsl)	566.5
Province		KZN	Depth (m)	0.79
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.48	Orthic A: Dry; Black; Loose; Granular; Loam; Medium grained soil		
0.48	0.79	Lithocunatic B: Dry; Brown Yellow; Hard; Granular; Sandy; Fine grained; Residual soil with lithic fragments		
Soil form		Glenrosa		

Auger hole logging data sheet				
Hole ID:		CA4	Latitude	-28.715813
Project:		Jindal Mine Hydroped	longitude	31.456895
Project No:		20-1221	Elevation (m amsl)	548
Province		KZN	Depth (m)	1.62
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.48	Orthic A: Dry; Black; Loose; Granular; Loam; Medium grained soil		
0.48	1.62	Lithocunatic B: Dry; Brown Yellow; Hard; Granular; Sandy; Fine grained; Residual soil with lithic fragments		
Soil form		Glenrosa		

Auger hole logging data sheet				
Hole ID:		CA6	Latitude	-28.714733
Project:		Jindal Mine Hydroped	longitude	31.455387
Project No:		20-1221	Elevation (m amsl)	
Province		KZN	Depth (m)	3
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.15	Orthic A: Dry; Brown; Soft; Granular; Loam; Fine grained soil		
0.15	1.82	Yellow Brown Apedal B: Moist; Yellow Brown; Firm; Blocky; loam; fine grained soil		
1.82	3	Unspecified B/Saprolite: Moist; Brown Yellow; Loose; Granular; Clayey loam; Fine grained; Residual soil		
Soil form		Clovelly		

Auger hole logging data sheet				
Hole ID:		CA7	Latitude	-28.713361
Project:		Jindal Mine Hydroped	longitude	31.45624
Project No:		20-1221	Elevation (m amsl)	551
Province		KZN	Depth (m)	1.35
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.52	Orthic A: Dry; Dark Grey; Loose; Granular; Loam; Medium grained soil		
0.52	1.35	Lithocunatic B: Dry; Reddish Brown; Hard; Granular; Sandy; Fine grained; Residual soil with lithic fragments		
Soil form		Glenrosa		

Auger hole logging data sheet				
Hole ID:		CA8	Latitude	-28.713141
Project:		Jindal Mine Hydroped	longitude	31.457342
Project No:		20-1221	Elevation (m amsl)	529
Province		KZN	Depth (m)	1.25
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.34	Orthic A: Dry; Reddish brown; Loose; Granular; Loam; Medium grained soil		
0.34	1.47	Lithocunatic B: Dry; Reddish Brown; Hard; Granular; Sandy; Fine grained; Residual soil with rock fragments		
Soil form		Glenrosa		

Auger hole logging data sheet					
	Hole ID:		CA9	Latitude	-28.7131
	Project:		Jindal Mine Hydroped	longitude	31.455214
	Project No:		20-1221	Elevation (m amsl)	548
	Province		KZN	Depth (m)	1.1
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.42	Orthic A: Dry; Reddish brown; Loose; Granular; Loam; Medium grained soil		
	0.42	1.1	Lithocunatic B: Dry; Reddish Brown; Hard; Granular; Sandy; Fine grained; Residual soil with rock fragments		
	Soil form		Glenrosa		

Processing plant

Auger hole logging data sheet			
Hole ID:	PA1	Latitude	-28.70684
Project:	Jindal Mine Hydroped	longitude	31.443596
Project No:	20-1221	Elevation (m amsl)	635.15
Province	KZN	Depth (m)	1.65
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.85	Orthic A: Moist; Dark Brown; Friable; Granular-Blocky; Fine; Loamy soil
0.85	1.65	Red Apedal B: Moist; Red; Friable; Granular; fine to medium grained; Loamy soil.
Comment		A and B seperated by a stone line (< 5 cm)
Soil form		Hutton

Auger hole logging data sheet			
Hole ID:	PA2	Latitude	-28.7077
Project:	Jindal Mine Hydroped	longitude	31.44457
Project No:	20-1221	Elevation (m amsl)	639.08
Province	KZN	Depth (m)	2.15
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.35	Orthic A: Dry; Browinsh Yellow; loose Granular; Loam; Medium grained soil
0.35	1.48	Lithocunatic B: Moist; Whitish Brown; Hard; Granular; Sandy; medium grained; Residual soil with lithic fragments
1.48	2.15	Saprolite: Moist; White; Loose; Granular; Coarse grained; Sandy; Residual soil (Signs of highly weathered granite)
Soil form		Glenrosa

Auger hole logging data sheet			
Hole ID:	PA3	Latitude	-28.707013
Project:	Jindal Mine Hydroped	longitude	31.444902
Project No:	20-1221	Elevation (m amsl)	626.77
Province	KZN	Depth (m)	2.7
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.38	Orthic A: Dry; Grey; Loose; Granular; Loam; Medium grained soil
0.38	2.7	Lithocunatic B: Moist; Brownish Yellow; Hard; Granular; Sandy; medium grained; Residual soil with lithic fragments
Soil form		Glenrosa

Auger hole logging data sheet			
Hole ID:	PA4	Latitude	-28.70648
Project:	Jindal Mine Hydroped	longitude	31.445077
Project No:	20-1221	Elevation (m amsl)	620.15
Province	KZN	Depth (m)	3
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.15	Orthic A: Moist; Reddish Brown; Friable; Subangular; Fine grained; loam soil.
0.15	3	Red Apedal B: Moist; Red; Friable; Sub-Angular; fine to medium grained; Loamy soil.
Soil form		Hutton

Auger hole logging data sheet			
Hole ID:	PA5	Latitude	-28.706507
Project:	Jindal Mine Hydroped	longitude	31.446413
Project No:	20-1221	Elevation (m amsl)	602.315
Province	KZN	Depth (m)	1.85
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.3	Orthic A: Dry; Grey; Loose; Granular; Loam; Medium grained soil
0.3	1.85	Lithocunatic B: Moist; Brownish; Hard; Granular; Sandy; medium grained; Residual soil with lithic fragments.
		Weathered granite.
Soil form		Glenrosa

Auger hole logging data sheet			
Hole ID:	PA6	Latitude	-28.707616
Project:	Jindal Mine Hydroped	longitude	31.443259
Project No:	20-1221	Elevation (m amsl)	638
Province	KZN	Depth (m)	1.42
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.35	Orthic A: Moist; Dark Grey; Friable; Granular-Blocky; Fine; Loamy soil
0.35	1.42	Red Apedal B: Moist; Red; Friable; Granular; fine to medium grained; Loamy soil.
Soil form		Hutton

Auger hole logging data sheet					
	Hole ID:		PA8	Latitude	-28.708675
	Project:		Jindal Mine Hydroped	longitude	31.445472
	Project No:		20-1221	Elevation (m amsl)	632.03
	Province		KZN	Depth (m)	1.56
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.15	Orthic A: Moist; Brown; Friable; Granular-Blocky; Fine grained; Loamy soil		
	0.15	1.18	Red Apedal B: Moist; Red; Friable; Blocky; fine to medium grained; Loamy soil.		
	1.18	1.56	Unspecified B/Saprolite: Moist; Pinkish White; Loose; Granular; Medium grained; Sandy soil; Residual soil.		
	Soil form		Hutton		

Auger hole logging data sheet					
	Hole ID:		PA9A	Latitude	-28.708313
	Project:		Jindal Mine Hydroped	longitude	31.446991
	Project No:		20-1221	Elevation (m amsl)	595.62
	Province		KZN	Depth (m)	2.56
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.47	Orthic A: Moist; Brown; Friable; Granular-Blocky; Fine grained; Loamy soil		
	0.47	2.54	Red Apedal B: Moist; Red; Friable; Blocky; fine to medium grained; Loamy soil.		
	Soil form		Hutton		

Auger hole logging data sheet					
	Hole ID:		PA9B	Latitude	-28.709828
	Project:		Jindal Mine Hydroped	longitude	31.447168
	Project No:		20-1221	Elevation (m amsl)	621.62
	Province		KZN	Depth (m)	3
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.3	Orthic A: Moist; Brown; Friable; Granular; Loam; Fine grained soil		
	0.3	3	Yellow Brown Apedal B: Moist; Yellow brown; Friable; Blocky; loam; Fine grained soil.		
	Soil form		Clovelly		

Auger hole logging data sheet			
Hole ID:	PA10	Latitude	-28.709438
Project:	Jindal Mine Hydroped	longitude	31.447718
Project No:	20-1221	Elevation (m amsl)	611.14
Province	KZN	Depth (m)	3
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.57	Orthic A: Moist; Brown; Friable; Granular-Blocky; Fine grained; Loamy soil
0.57	3	Red Apedal B: Moist; Red; Friable-Firm; Blocky; fine to medium grained; Loamy soil.
Soil form		Hutton

Auger hole logging data sheet			
Hole ID:	PA11	Latitude	-28.709827
Project:	Jindal Mine Hydroped	longitude	31.445751
Project No:	20-1221	Elevation (m amsl)	628.76
Province	KZN	Depth (m)	1.7
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.56	Orthic A: Moist; Brown; Friable; Granular; Loam; Fine grained soil
0.56	1.7	Yellow Brown Apedal B: Moist; Yellow brown; Friable; Blocky; loam; Fine grained soil.
Soil form		Clovelly

Auger hole logging data sheet			
Hole ID:	PA12	Latitude	
Project:	Jindal Mine Hydroped	longitude	
Project No:	20-1221	Elevation (m amsl)	616.35
Province	KZN	Depth (m)	
Logged by	Siphe	Water level (mbgl)	-

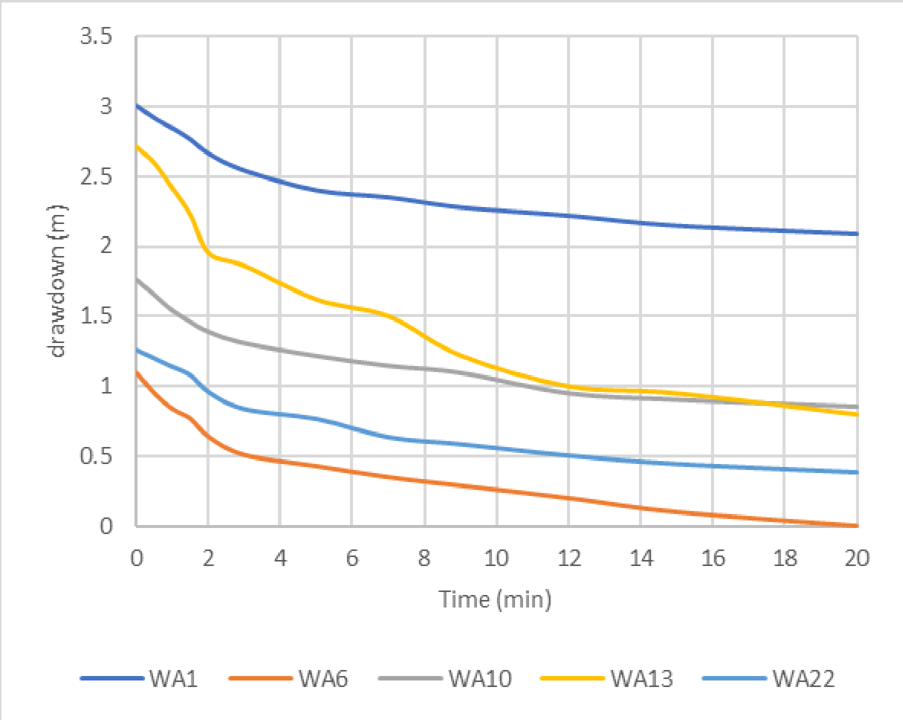
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.18	Orthic A: Moist; Brown; Friable; Granular; Loam; Fine grained soil
0.18	1.32	Yellow Brown Apedal B: Moist; Yellow brown; Friable; Blocky; loam; Fine grained soil.
1.32	3	Unspecified B/Saprolite: Moist; Weak Yellow; Loose; Granular; Sandy; fine grained soil
Soil form		Clovelly

Auger hole logging data sheet					
	Hole ID:		PA13	Latitude	-28.711631
	Project:		Jindal Mine Hydroped	longitude	31.447162
	Project No:		20-1221	Elevation (m amsl)	594.7
	Province		KZN	Depth (m)	1.42
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.16	Orthic A: Moist; Dark Grey; Friable; Granular-Blocky; Fine grained; Loamy soil		
	0.16	1.1	Red Apedal B: Moist; Red; Firm; Blocky; fine to medium grained; Loamy soil.		
	1.1	1.42	Unspecified B/Saprolite: Moist; Yellow Brown; Firm-Friable; Granular-Blocky; Loamy; Fine grained soil		
	Soil form		Hutton		

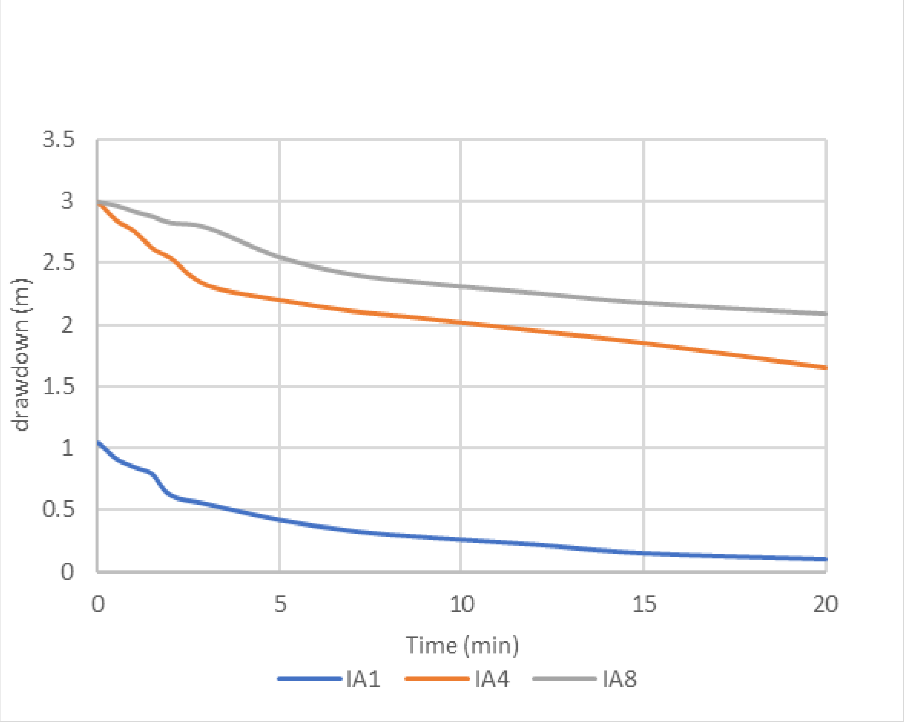
Auger hole logging data sheet					
	Hole ID:		PA14	Latitude	-28.712152
	Project:		Jindal Mine Hydroped	longitude	31.446228
	Project No:		20-1221	Elevation (m amsl)	579.85
	Province		KZN	Depth (m)	3
	Logged by		Siphe	Water level (mbgl)	-
	From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
	0	0.24	Orthic A: Moist; Dark Brown; Friable; Granular-Blocky; Fine grained; Loamy soil		
	0.24	2.25	Red Apedal B: Moist; Red; Firm; Blocky; fine to medium grained; Loamy soil.		
	2.25	3	Unspecified B/Saprolite: Moist; Yellow Brown; Friable; Granular; Loamy; Fine grained soil.		
	Soil form		Hutton		

Permeability Testing

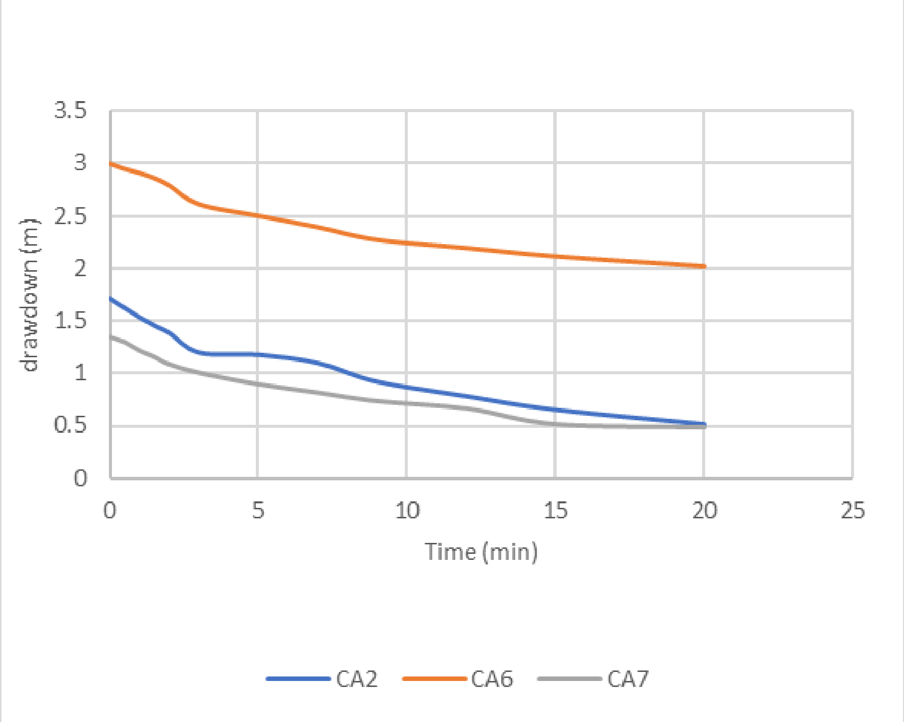
Waste Dump					
Time Elapsed (min)	**Falling Head (m)**				
	WA1	**WA6**	**WA10**	**WA13**	**WA22**
0	3	1.1	1.76	2.71	1.26
0.5	2.91	0.95	1.65	2.59	1.2
1	2.84	0.84	1.54	2.41	1.14
1.5	2.76	0.77	1.46	2.22	1.08
2	2.66	0.64	1.39	1.95	0.96
3	2.54	0.51	1.31	1.86	0.84
5	2.4	0.43	1.22	1.62	0.77
7	2.35	0.35	1.15	1.5	0.64
9	2.28	0.29	1.1	1.22	0.59
12	2.22	0.2	0.955	1	0.51
15	2.15	0.1	0.91	0.95	0.45
20	2.09	0	0.86	0.8	0.39



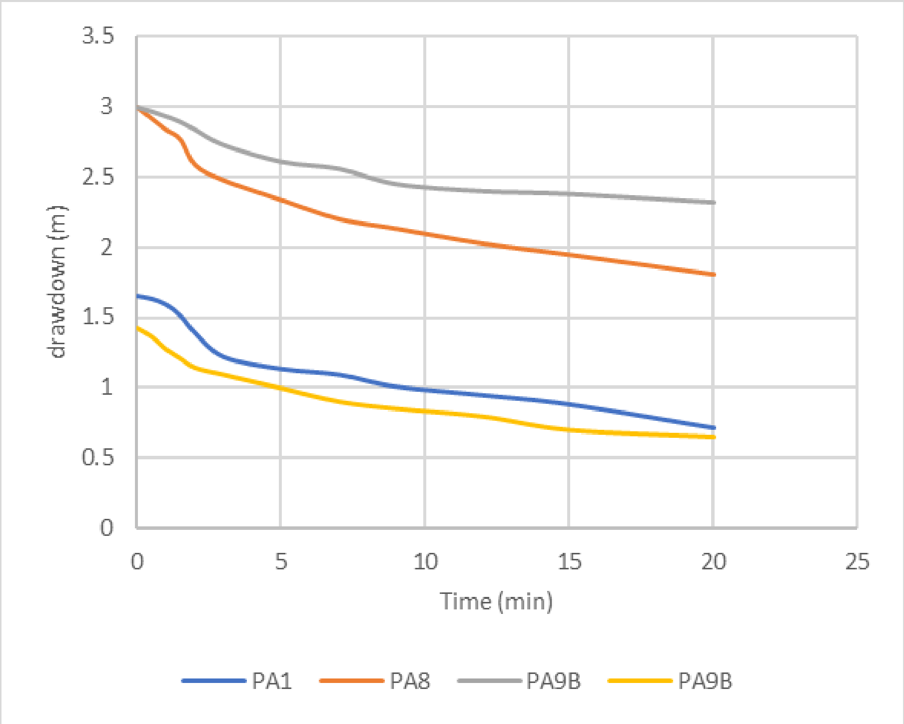
Incoming Power Yard			
Time Elapsed (min)	**Falling Head (m)**		
	IA1	**IA4**	**IA8**
0	1.05	3	3
0.5	0.92	2.85	2.97
1	0.85	2.76	2.92
1.5	0.79	2.62	2.88
2	0.62	2.54	2.83
3	0.55	2.32	2.79
5	0.42	2.2	2.55
7	0.33	2.11	2.41
9	0.28	2.05	2.34
12	0.22	1.95	2.26
15	0.15	1.85	2.18
20	0.1	1.65	2.09



Primary Crusher			
Time Elapsed (min)	**Falling Head (m)**		
	CA2	**CA6**	**CA7**
0	1.72	3	1.35
0.5	1.63	2.95	1.3
1	1.54	2.91	1.22
1.5	1.46	2.86	1.16
2	1.39	2.79	1.09
3	1.2	2.61	1.01
5	1.18	2.5	0.9
7	1.1	2.39	0.82
9	0.92	2.27	0.74
12	0.78	2.19	0.67
15	0.65	2.11	0.52
20	0.51	2.015	0.49



Processing Plant				
Time Elapsed (min)	**Falling Head (m)**			
	PA1	**PA8**	**PA9B**	**PA13**
0	1.65	3	3	1.42
0.5	1.63	2.92	2.97	1.36
1	1.59	2.84	2.935	1.27
1.5	1.51	2.77	2.895	1.205
2	1.39	2.59	2.84	1.14
3	1.22	2.48	2.73	1.09
5	1.135	2.34	2.61	0.995
7	1.095	2.205	2.56	0.9
9	1.01	2.135	2.45	0.85
12	0.95	2.03	2.4	0.795
15	0.885	1.95	2.38	0.7
20	0.72	1.81	2.32	0.65



APPENDIX C: LABORATORY CERTIFICATES

TALBOT
A Level 2 B-BBEE company

[003843/21], [2021/06/02]

Certificate of Analysis

Project details

Customer Details

Customer reference:	MELMOTH IRON ORE (20-1221)
Order number:	20-1221
Company name:	GCS (PTY) LTD DURBAN
Contact address:	P O BOX 819, GILLITS, 3603
Contact person:	HENRI BOTHA

Sampling Details

Sampled by:	CUSTOMER
Sampled date:	2021/05/28

Sample Details

Sample type(s):	SOIL SAMPLES
Date received:	2021/05/31
Delivered by:	CUSTOMER - GILLITTS DEPOT
Temperature at sample receipt (°C):	20.4

Report Details

Testing commenced:	2021/05/31
Testing completed:	2021/06/02
Report date:	2021/06/02
Our reference:	003843/21

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Analytical Results

Methods	Determinands	Units	W00764/21 MELMOTH IRON ORE: PA8 28.05.2021	W00765/21 MELMOTH IRON ORE: PA9 28.05.2021
Chemical				
142	>2000 µm*	% g/g	17	12
142	1000 - 2000 µm*	% g/g	12	4.4
142	500 - 1000 µm*	% g/g	19	20
142	250 - 500 µm*	% g/g	19	16
142	125 - 250 µm*	% g/g	21	33
142	63 - 125 µm*	% g/g	9.0	11
142	<63 µm*	% g/g	2.4	2.6

Methods	Determinands	Units	W00766/21 MELMOTH IRON ORE: PA14 28.05.2021	W00767/21 MELMOTH IRON ORE: IA4 27.05.2021
Chemical				
142	>2000 µm*	% g/g	19	18
142	1000 - 2000 µm*	% g/g	14	17
142	500 - 1000 µm*	% g/g	23	22
142	250 - 500 µm*	% g/g	14	23
142	125 - 250 µm*	% g/g	17	12
142	63 - 125 µm*	% g/g	10	5.8
142	<63 µm*	% g/g	2.6	1.7

Methods	Determinands	Units	W00768/21 MELMOTH IRON ORE: IA9 27.05.2021	W00769/21 MELMOTH IRON ORE: CA4 24.05.2021
Chemical				
142	>2000 µm*	% g/g	20	29
142	1000 - 2000 µm*	% g/g	18	23
142	500 - 1000 µm*	% g/g	19	23
142	250 - 500 µm*	% g/g	19	13
142	125 - 250 µm*	% g/g	10	6.3
142	63 - 125 µm*	% g/g	10	3.7
142	<63 µm*	% g/g	1.8	1.5

Methods	Determinands	Units	W00770/21 MELMOTH IRON ORE: CA7 26.05.2021	W00771/21 MELMOTH IRON ORE: WA2 24.05.2021
Chemical				
142	>2000 µm*	% g/g	41	34
142	1000 - 2000 µm*	% g/g	27	25
142	500 - 1000 µm*	% g/g	14	18

Talbot Laboratories (Pty) Ltd Reference: [003843/21] Page 2 of 5

Methods	Determinands	Units	W00770/21 MELMOTH IRON ORE: CA7 26.05.2021	W00771/21 MELMOTH IRON ORE: WA2 24.05.2021
142	250 - 500 µm*	% g/g	8.0	10
142	125 - 250 µm*	% g/g	4.7	6.0
142	63 - 125 µm*	% g/g	3.9	4.8
142	<63 µm*	% g/g	1.8	0.96

Methods	Determinands	Units	W00772/21 MELMOTH IRON ORE: WA6 24.05.2021	W00773/21 MELMOTH IRON ORE: WA13 25.05.2021
Chemical				
142	>2000 µm*	% g/g	65	17
142	1000 - 2000 µm*	% g/g	9.6	26
142	500 - 1000 µm*	% g/g	11	22
142	250 - 500 µm*	% g/g	8.0	13
142	125 - 250 µm*	% g/g	2.9	11
142	63 - 125 µm*	% g/g	3.0	9.1
142	<63 µm*	% g/g	0.34	1.8

Methods	Determinands	Units	W00774/21 MELMOTH IRON ORE: WA14 25.05.2021	W00775/21 MELMOTH IRON ORE: WA17 25.05.2021
Chemical				
142	>2000 µm*	% g/g	33	28
142	1000 - 2000 µm*	% g/g	21	19
142	500 - 1000 µm*	% g/g	19	21
142	250 - 500 µm*	% g/g	14	16
142	125 - 250 µm*	% g/g	8.1	11
142	63 - 125 µm*	% g/g	4.1	3.6
142	<63 µm*	% g/g	0.92	0.87

Methods	Determinands	Units	W00776/21 MELMOTH IRON ORE: WA22 25.05.2021
Chemical			
142	>2000 µm*	% g/g	47
142	1000 - 2000 µm*	% g/g	19
142	500 - 1000 µm*	% g/g	11
142	250 - 500 µm*	% g/g	8.3
142	125 - 250 µm*	% g/g	5.6
142	63 - 125 µm*	% g/g	6.0
142	<63 µm*	% g/g	2.9

Refer to the "Notes" section at the end of this report for further explanations.

Specific Observations

None

Quality Assurance

Technical signatories

Inorganic Chemistry: Denise Naidoo

Notes to this report

Limitations

This report shall not be reproduced except in full without prior written approval of the laboratory.
Results in this report relate only to the samples as taken, and the condition received by the laboratory.
Any opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
The decision rule applicable to this laboratory is available on request.
Sample preparation may require filtration, dilution, digestion or similar. Final results are reported accordingly.
Where the laboratory has undertaken the sampling, the location of sampling and sampling plan are available on request. Talbot Laboratories is guided by the National Standards SANS 5667-3:2006 Part 3 Guidance on the Preservation and Handling of Water Samples; SANS 5667-1:2008 Part 1 Guidance on the Design of Sampling Programmes and Sampling Techniques and SANS 5667-2:1991 Part 2: Guidance on Sampling Techniques.
Customers to contact Talbot Laboratories for further information.

Uncertainty of measurement

Talbot Laboratories' Uncertainty of Measurement (UoM) values are:

- Identified for relevant tests.
- Calculated as a percentage of the respective results.
- Applicable to total, dissolved and acid soluble metals for ICP element analyses.
- Available upon request.

Analysis explanatory notes

Tests may be marked as follows:

^	Tests conducted at our Port Elizabeth satellite laboratory.
*	Tests not included in our Schedule of Accreditation and therefore that are not SANAS accredited.
#	Tests that have been sub-contracted to a peer laboratory.
NR	Not required -shown, for example, where the schedule of analysis varied between samples.
σ	Field sampling point on-site results.
ª	Testing has deviated from Method.

*****End of Report*****

APPENDIX D: DISCLAIMER

The opinions expressed in this Report have been based on site /project information supplied to GCS (Pty) Ltd by SLR and are based on public domain data, field data and data supplied to GCS by the client. GCS has acted and undertaken this assessment objectively and independently.

GCS has exercised all due care in reviewing the supplied information. Whilst GCS has compared key supplied data with expected values, the accuracy of the results and conclusions are entirely reliant on the accuracy and completeness of the supplied data. GCS does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

Opinions presented in this report, apply to the site conditions, and features as they existed at the time of GCS's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this report, about which GCS had no prior knowledge nor had the opportunity to evaluate.

APPENDIX E: HYDROPEDOLOGY GUIDELINES

Guideline for hydropedological Assessments and Minimum Requirements

Introduction

This guideline was developed by Prof Johan van Tol and colleagues all scientists in the field of hydropedological sciences. It culminated after various WRC and other research projects where DWS were involved at different levels. The authors of this document *Van Tol, J.J., Bouwer, D. & Le Roux, P.A.L., 2021* are at the cutting edge of the developments in the field of Hydropedology, all of them either from the University of the Free State (UFS) or previously from UFS. DWS had various interactions with the research team, even people not mentioned, and this eventually culminated in this approach where DWS as the regulator can now adopt these methods of assessing the relevant aspects of hillslope hydrology that can influence decision-making positively in a consistent and standardized method.

Background

Hydropedological surveys aim to characterise dominant surface and sub-surface flow paths of water through the landscape to wetlands and streams or groundwater. The objective of these guidelines is to standardise hydropedological survey methodology to identify dominant hydrological drivers and responses of landscapes to quantify the impact of new development on water resources. This will assist decision-makers to understand the hydrological system and thereby make sensible decisions with regard to sustainable water management. These guidelines were developed from numerous scientific and consultancy projects (van Tol, 2020) and are divided into four steps:

1) Identification of dominant hillslopes.
2) Conceptualising hillslope hydropedological responses.
3) Quantification of hydraulic properties and flow rates.
4) Quantification of hydropedological fluxes.

The first two steps should be conducted for any impact assessment requiring a hydropedological survey. Steps 3 and 4 will typically be required where drastic land-use change or planned e.g. open-pit mining, large developments which will obstruct lateral flow paths.

Guidelines

Step 1: Identification of the representative hillslope/s

- Identify land types (Land Type Survey Staff, 1972 – 2006) within the study area.
- Identify dominant hillslopes (from crest to stream) of the study area using terrain analysis.
  - There should be at least one hillslope in each land type of the study area.

- Hillslopes should be representative of the topography (e.g. slope, aspect and curvature) and land types.
    - For example, where the site is divided by a stream, a representative hillslope should be identified on both sides of the stream.

Step 2: Conceptualize hillslope hydropedological responses

Transect survey

- A transect soil survey should be conducted on each of the identified hillslopes (Le Roux et al., 2011).
- Soil observations should be made at regular intervals, not exceeding 100 m, on the transect.
- Profile pits of representative soil forms should be opened to proper description, photographs and collection of undisturbed samples.
- Observation depth should be until refusal. Where the soil depth exceeds 2 m, auger observations must be made at the bottom of the pit to describe the soil/saprolite/bedrock transition.

Soil description and classification

- Soils should be described and classified in accordance with the South African Soil Classification system up to the family level (Soil Classification Working Group, 2018).
- The following morphological properties should be described:
    - Thickness of horizons
    - Structure (size, grade, type)
    - Estimated texture
    - Matrix Munsel colour (moist and dry)
    - Mottles (colour, size, frequency, prominence and type)
    - Concretions (colour, size, frequency, prominence and type)
    - Precipitation of carbonates, gypsum or salts
    - Roots (abundance)
    - Macropores (frequency and size)
    - Nature of transition between horizons/bedrock/saprolite
- The profile should then be regrouped into one of the seven hydropedological groups (van Tol & Le Roux, 2019).

Conceptual hillslope hydropedological response

- The occurrence, sequence and coverage of the different hydropedological groups on a transect must then be used to describe the hydrological behaviour of the hillslope (van Tol et al., 2013).

- This will include a graphical representation of the dominant and sub-dominant flow paths at the hillslope scale before development. This will include:

- Overland flow
- Subsurface lateral flow
- Bedrock flow and
- Return flow
- Storage mechanisms

- The impact of the proposed development on hydropedological behaviour should also be graphically presented. This should typically include the location of the development on the hillslope and the anticipated impact of the development on water flows.

Step 3: Quantification of hydraulic properties and flowrates

- From the transect survey (steps 1 and 2) representative soil forms and horizons should be identified.
- Soil physical/hydraulic properties should then be measured for representative horizons using standard procedures. This should include (but is not limited to) to:
  - Particle size distribution
  - Porosity/bulk density
  - Conductivity/permeability
- Measurements should then be related to the conceptualised hydropedological response model to provide a quantitative description of flow rates and storage.

Step 4: Quantification of hydropedological fluxes

- Hydropedological fluxes of water before and after development can be quantified using the:

i. Long-term hydrometric measurements

or

ii. Modelling/simulations of the hydropedological response

- When the fluxes will be quantified using modelling, it is important that the selected model is capable of reflecting hydropedological processes (especially lateral fluxes) at the hillslope scale. Suggested models are
  - SWAT+ (Bieger et al., 2017; van Tol et al., 2020a).
  - Catchment Modelling Framework (Kraft et al., 2011; van Tol et al., 2020b).
  - Hydrus 2/3D for small hillslopes (Simunek et al., 2006; van Zijl et al., 2020).
- The model should be configured using the actual soil distribution and parameterized using measured properties (step 3) under realistic climatic scenarios.
- Model runs should include a pre-development set-up (baseline) as well as one or more runs where the proposed development is included in the model configuration (post-development).
  - Post-development modelling should preferably consider more than one scenario such as different size buffers or more than one developmental layout.

- Model outputs that should be considered and compared to the baseline include (but are not limited to):
  - Impact on streamflow
  - Impact on wetland water regimes
  - Impact on lateral flow to the wetland
  - Impact on overland flow and associated risk of water erosion.

References

Bieger, K., Arnold, J.G., Rathjens, H., White, M.J., Bosch, D.D. & Allen, P.M., 2017. Introduction to SWAT+, a Completely Restructured Version of the Soil and Water Assessment Tool. *Journal of the American Water Resources Association* 53, 115 – 130.

Kraft, P., Vaché, K.B., Frede, H.-G. Breuer, L. 2011. A hydrological programming language extension for integrated catchment models, Environmental Modelling & Software, DOI: 10.1016/j.envsoft.2010.12.009

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APPENDIX F: DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Hydropedological Assessment for the Proposed Melmoth Iron Ore Mine

SPECIALIST INFORMATION

Specialist Company Name:	GCS Water and Environment Pty Ltd			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	2	Percentage Procurement Recognition	
Specialist name:	Hendrik Botha			
Specialist Qualifications:	MSc Environmental Sciences (Geohydrology & Geochemistry) BSc Hons. Environmental Sciences (Hydrology) BSc. Geology and Chemistry			
Professional affiliation/registration:	PR SCI NAT 400139/17			
Physical address:	1 Karbochem Road, Newcastle, KZN			
Postal address:				
Postal code:	2940	Cell:		
Telephone:	071 102 3819	Fax:		
E-mail:	hendrikb@gcs-sa.biz			

DECLARATION BY THE SPECIALIST

I, _Hendrik Botha, declare that –

- I act as the independent specialist in this application.
- I will perform the work relating to the application objectively, even if this results in views and findings that are not favourable to the applicant.
- I declare that there are no circumstances that may compromise my objectivity in performing such work.
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity.
- I will comply with the Act, Regulations, and all other applicable legislation.
- I have no, and will not engage in, conflicting interests in the undertaking of the activity.
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken concerning the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

12/12/2022
7:49:13

Signature of the Specialist

GCS

Name of Company:

12 December 2022

Date

CV OF SPECIALIST

Hendrik Botha

Technical Director

LinkedIn:

CORE SKILLS

- Project management
- Analytical and numerical groundwater modelling
- Geochemical assessments and geochemical modelling
- Hydropedology, hydrological assessments & yield assessments
- Hydrology, floodline modelling & storm water management
- Groundwater vulnerability, impact, and risk assessments
- Technical report writing
- GIS and mapping

DETAILS

Qualifications

- BSc Chemistry and Geology (Environmental Sciences) (2012)
- BSc Hons Hydrology (Environmental Sciences) (2013)
- MSc Geohydrology and Hydrology (Environmental Sciences) (2014-2016)

Membership

- Groundwater Division of GSSA
- Groundwater Association of KwaZulu Natal Member
- International Mine Water Association (IMWA)

Languages

- Afrikaans - Speak, read, write.
- English - Speak, read, write.

Projects undertaken in

- South Africa
- Nigeria
- Namibia
- Liberia

PROFILE

Hendrik (Henri) Botha is currently the manager of the GCS Newcastle Office and occupies the role of principal hydrogeologist. Groundwater, geochemistry and surface hydrology, as well as knowledge of water chemistry together with GIS, and analytical and numerical modelling skills, are some of his sought-after expertise. General and applied logical knowledge are his key elements in problem-solving.

Professional Affiliations:

SACNASP Professional Natural Scientist (400139/17)

Areas of Expertise:

- Waste classification and Impact Assessments
- Aquifer vulnerability assessments
- Geochemical sampling, data interpretation and modelling
- Geophysical surveys and data interpretation
- GIS
- Water quality sampling and data interpretation
- Groundwater impact and risk assessments
- Numerical and Conceptual Visual Modelling (Visual Modflow, ModflowFLEX, Voxler, RockWorks, Surfer and Excel)
- Hydropedology (Hydrological Soil Types) & Soils Assessments
- Floodline Modelling (HEC-RAS)
- Stormwater Management Systems and Modelling
- Surface Water Yield Assessments
- Water and Salt Balances

SCAN ME
PROJECT RECORD

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