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OMITIOMIRE COPPER PROJECT

HYDROGEOLOGY SPECIALIST STUDY

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1	Issued in Final	20 March 2024

Knight Piésold CONSULTING

EXECUTIVE SUMMARY

Craton Mining and Exploration (PTY) Ltd is completing a Bankable Feasibility Study for the Omitiomire Copper Mine Project in central Namibia. The project comprises an open pit, waste rock dump, heap leach pad and processing plant for the planned copper mining operation. Knight Piésold Consulting was appointed to complete a hydrogeology specialist study.

The hydrogeological study for the Omitiomire Copper Mine includes a desktop study, fieldwork, and conceptual and numerical groundwater modelling.

CLIMATE

The Omitiomire climate is characterised by semi-arid conditions, with the wet season spanning from November to February. The rainfall is of short duration but high intensity, also known as flash flood rainfall events, and is characterised by extreme spatial and temporal variability. The mean annual precipitation (MAP) on-site from 2008 to 2011 is 508 mm, but it is more likely that the MAP in the longer term is less and close to the catchment MAP from 400 to 450 mm.

GEOLOGY

The dominant geological feature at Omitiomire is the Ekuja Basement Dome, which comprises millimetre to ten-metre scale alternating felsic rock, amphibolite and amphibole-biotite schist. The Dome is surrounded by the Swakop lithologies of the Damara sequence, consisting of a lower sequence of quartzite and calc-silicate rock and a very thick upper layer of schist. The Kuiseb Formation rocks (mica schist, amphibolite, quartzite, and graphite schist) are present to the south. A thin unit of the Kalahari Group Sediments and Quaternary deposits unconformably overlies these sequences.

The ore is a tabular copper deposit, striking north-south and dipping at a shallow angle (around 20°C - 30°C) to the east. The deposit is about 10 m thick near the surface but widens to the east.

GEOPHYSICS

An Electrical Resistivity Tomography (ERT) geophysical survey identified faults that were interpreted to be of Karoo age, generally steeply dipping, and likely water-bearing. These were used to position hydrogeological exploration boreholes.

HYDROGEOLOGY

There are two significant aquifers: the shallow aquifer, an unconfined weathered aquifer associated with the alluvium along drainage channels, and the deep aquifer, the confined fractured aquifer in the hard rock. The unconfined aquifer comprises silty sand, is about 10m – 20m deep, and is strongly influenced by recharge and evaporation. The deep fractured aquifer has a low primary porosity with structurally controlled groundwater flow.

HYDROCENSUS AND AQUIFER TESTING

A local hydrocensus included measuring water levels from monitoring wells and exploration wells where accessible. The water levels in the area range from 15 to 30 metres below the surface (mbs), with deeper levels occurring in the southwest region.

The fault-targeted boreholes intercepted water strikes at the expected fault depth and were 32-33 mbs for HYBH01 and 92-93 mbs for HYBH04. The regional groundwater level data shows shallow water strikes range from 23-40 mbs, and the deep fractured aquifer ranges from 53-91 mbs.

The data obtained from the aquifer tests shows that the aquifer falls within the expected range for fractured igneous and metamorphic rocks with intermediate permeability (0.01 to 0.1 m/day). The observation wells did not respond to the pumping during the testing, indicating limited hydraulic connectivity in the water-bearing fractures.

GROUNDWATER LEVELS AND FLOW

The groundwater flow in the alluvials and shallow weathered rock is influenced by rainfall and evaporation, which can be seen from the fluctuating water levels in boreholes near the river. Generally, the groundwater level near the Nossob River is less than 20m below the surface.

Groundwater levels in the deeper regional aquifer range from 20 to 40 mbs and show a delayed response to recharge. The groundwater levels are shallower in the north, close to the catchment watershed and deepen to the southeast.

GROUNDWATER QUALITY

Groundwater samples were analysed at a SANAS-accredited laboratory in South Africa. Most samples have acceptable water quality per the Namibian Drinking Water (NDW) standards. Carbonate, bicarbonate anions, and magnesium and calcium cations dominate most water samples. The samples from the gneisses and amphibolites show a magnesium-bicarbonate-chemical signature, which typically indicates shallow fresh groundwater from recent recharge. The schists have a different signature with higher chloride and calcium ions, suggesting older groundwater has had time to interact with the rock.

GROUNDWATER NUMERICAL MODEL

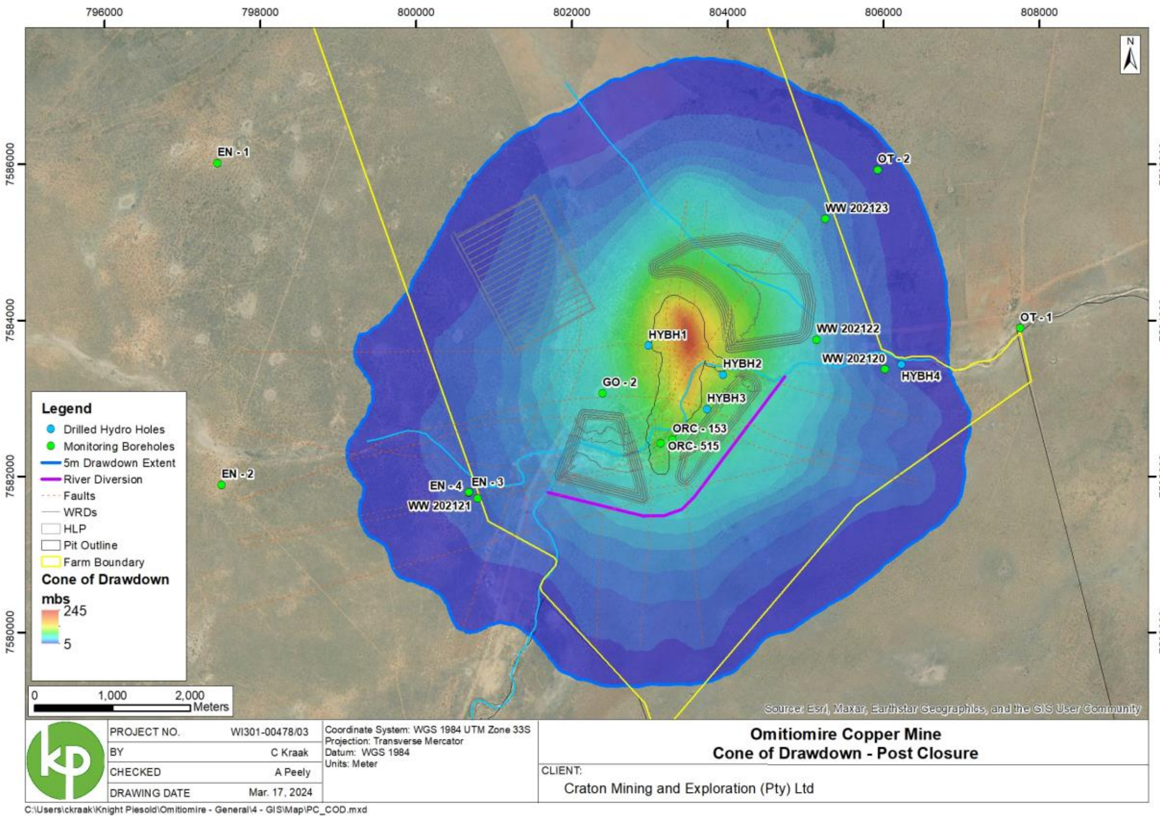
The hydrogeological conceptual model generated in Leapfrog Works® was used to create a 3D hydrogeological numerical model in DHI's FEFLOW 8 software and constructed using available data and information regarding geology and groundwater parameters. The purpose of the groundwater model is to understand the groundwater regime and how the proposed mining infrastructure may impact the region.

CALIBRATION

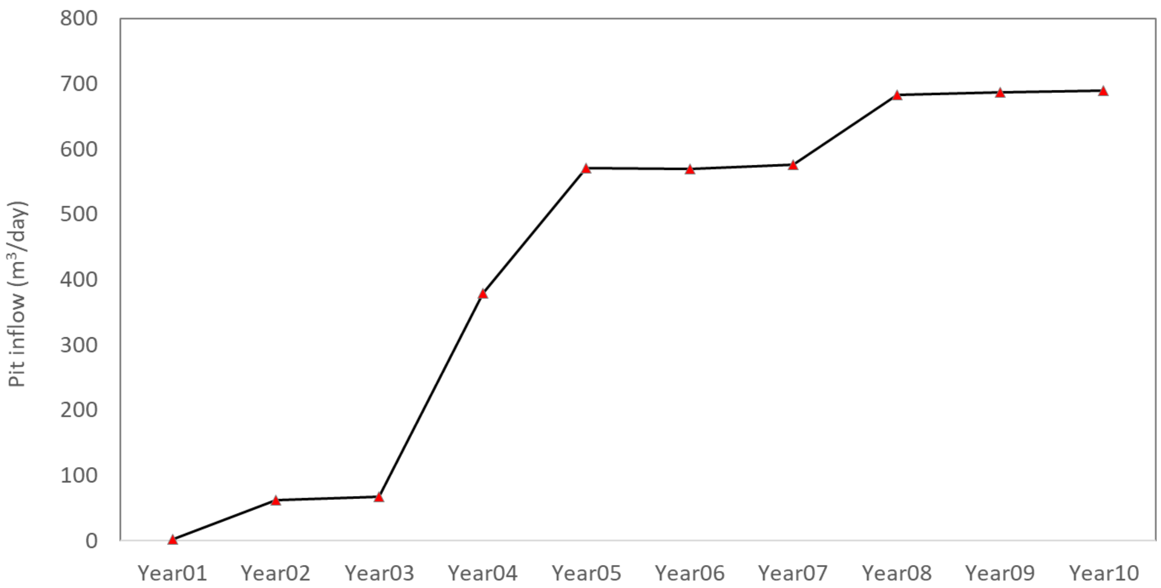
The model was calibrated to a Root Mean Square value of 6, which is considered suitable for this model. The calibrated hydraulic conductivities range from 0.002 m/d to 0.15 m/d for Kx and Ky; Kz is an order of magnitude lower than Kx.

PIT INFLOWS

The 10 years of design for the mine pit and WRD, as provided by the client, was incorporated in the numerical model for transient state modelling. The COD Is very steep and does not extend far from the pit. However, it does result in a phreatic surface drop with a very shallow gradient of 3 m at a maximum of 3.5 km along the structures from the pit centre at the life of mine. With the phreatic surface close to the pit wall, higher pore pressures may occur and can be managed with in-pit horizontal drainage. At maximum pit depth, the COD generated by the pit extends to a maximum of 4.5 km from the pit centre after 50 years post-closure and does not reach the Nossob River.



Due to the region's low recharge and low hydraulic conductivity of the host rock, the inflow volumes into the pit are minimal, reaching about 690 m^3/day by LOM. It must also be noted that Feflow does not take evaporation from the pit walls, direct rainfall into the pit, and overland flow into account. Therefore, pit inflows can be managed through pit sumping with a contingency for higher inflows or direct precipitation in the pit dewatering reticulation design.



The pit base inflow over the 10 years of the mine pit plans.

PIT DEWATERING

A dewatering scenario was simulated with 4 active pumping wells placed to target significant structures intercepting the pit. The pumping wells were set to abstract groundwater at 0.3 L/s. The effect on inflow volumes to the pit is small and does not significantly impact the pit wall pore pressures.

Apart from abstracting groundwater before it enters the pit and is exposed to associated contamination, using out-of-pit dewatering boreholes is not an effective strategy. Using horizontal wells/seep holes in the pit wall will be more cost-effective.

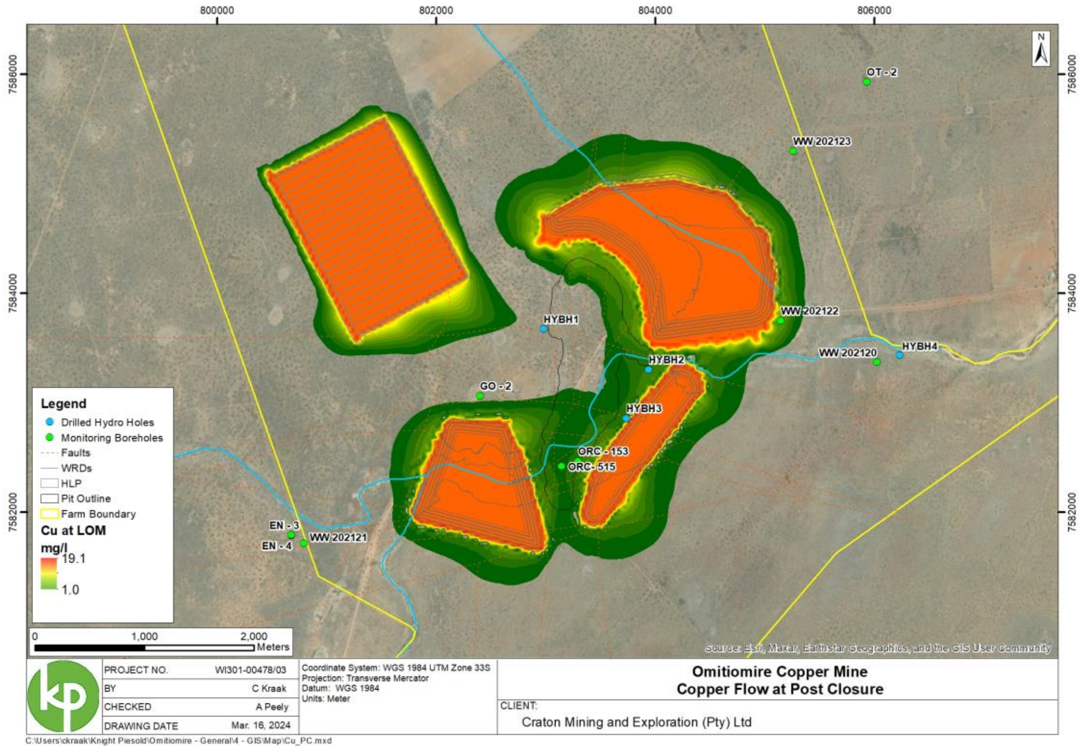
RIVER DIVERSION

The groundwater level is simulated to be 12 to 20 m below the ground surface. The channel will recharge the aquifer under high-gradient flow regimes (flooding conditions). However, after flooding subsides, the groundwater flow direction reverses. Once the pit excavations have deepened below 10m, the Cone of Drawdown extends past the river diversion, resulting in decoupling from the regional groundwater.

SOLUTE TRANSPORT

The model was developed to show the potential flow migration from the WRD and the HLP. Copper was selected to investigate the plume migration from the mine facilities. Geochemical analysis from humidity cell kinetic testing of the heap-leached residue shows that the maximum concentration of copper is 17.91 mg/l, which was used to simulate the worst-case scenario.

After the first 10 years, the solute reaches the saturated zone but will likely not migrate downstream considerably because of the pit capture zone. The maximum horizontal and vertical migration after 35 years post-closure of Cu with 1 mg/l concentration is 370 and 245 m, respectively. Once the solute enters the fractured aquifer, it gets drawn into the pit. After closure, the pit will continue acting as a regional sink and draw groundwater and potential contaminants towards the pit.



Cu mass transport in year 50

Risks and Opportunities

The risks associated with groundwater in the region are minimal, with low inflow volumes and limited solute migration from the waste facilities.

- Low confidence in the recharge values reduces the overall confidence of the model. Rainfall water quality can assist in the determination of a more accurate recharge rate for the aquifers. It is recommended that rainfall samples be collected each season based on availability to provide higher accuracy recharge values.
- Rainfall in the region is sporadic and results in episodic time-based recharge to the groundwater, which can impact inflow calculations in the model. It is recommended that daily rainfall events and volumes are recorded.
- The risks associated with groundwater in the region are minimal, with low inflow volumes and limited solute migration from the waste facilities. Quickflow from the waste rock dumps and runoff are excluded from the model outputs but could impact the Nossob River downstream of the mining infrastructure.
- Flooding of the pit after high rainfall events.
    - The low inflows that need to be managed (excluding direct rainfall and surface runoff into the pit) can be managed by in-pit sumping.
    - The mine water reticulation from the pit should consider a contingency allowance for high precipitation.
- Transient high pore pressures after high rainfall events or intercepting a water-bearing structure with high permeability and storage may temporarily increase inflows into the pit.
    - Installation of dewatering wells at targeted locations can mitigate the possibility of transient high pore pressures in the pit walls following rainfall events, particularly where the riverbed was before the diversion (with alluvials) is intercepted in the high pit walls or close to the pit walls.
    - In-pit horizontal drain holes installed locally during mining can be installed in areas of geotechnical weakness and/or high pore pressures to allow for the controlled dewatering of the area.
    - Vibrating wire transducers (VWTs) should be installed to monitor the seasonal pore pressure in different hydrostratigraphic units pre-mining to establish baseline conditions and during operations to monitor the impact of mining infrastructure, i.e. as the WRDs develop.
- The local water supply is limited, and it has been planned that the supply for the mine will be brought in from outside of this catchment. However, a few existing boreholes can supply small volumes to supplement the water supply.
    - Abstraction of the groundwater before it is exposed to contamination can be used to supplement the mine water supply.
- Solute migration from the mine waste facilities will move down-gradient. The installation of monitoring boreholes and piezometers is required, particularly on the original riverbed.
    - The monitoring wells can also act as scavenger wells should solute be picked up in the wells.
- The model predictions indicate a limited extent to the cone of drawdown, which is unlikely to impact the farmer's boreholes. However, unknown structures may increase the extent of the COD.
    - Regional groundwater monitoring should continue to monitor the COD extent and be used to update the model in real-time, increasing the model’s confidence.
- The river diversion provides an opportunity to divert fresh water around the mine infrastructure.

CONCLUSIONS

- The River Diversion will have minimal impact on the regional groundwater.
- Inflow rates to the pit are low, reaching about 690 m^3/day by LOM. This value does not account for evaporation, direct rainfall and overland flow into the pit.
- Active dewatering will not be necessary based on the simulated low inflow rates and high evaporation in the area. The water can be managed by pit sumping and localised horizontal drains if required.
- The 5m isopach of the COD has a maximum extent of 4.5 km after 50 years post-closure. The drawdown cone is narrow and steep at the pit and flattens out within a short distance from the pit.
- Plume migration from the WRD and HLP does not extend outside the farm boundary, and once the solute reaches the fractured aquifer, it gets drawn towards the pit.

RECOMMENDATIONS

The following recommendations are provided for the Omitiomire Copper Mine hydrogeology:

- Dedicated piezometers should be installed, including open hole and vibrating wire transducers targeting the alluvium aquifer and the hard rock aquifer separately.
- It is crucial to record complete information about the boreholes, including the depth at which they measure the groundwater level or pore pressure and the geological and structural conditions in which they are located.
- Global circulation models and a downscaling approach should be used to project precipitation in the future to calculate recharge based on climate change scenarios.
- Double-ring infiltrometer tests should be conducted in several parts of the project, including the WRDs, to determine the recharge coefficient.
- Additional drilling and test pumping targeting the schists is recommended to increase confidence in the hydraulic parameters.
- Obtain geotechnical logs and structural studies for the mine, focusing on water-bearing faults and joint sets.
- Packer testing or Borehole Magnetics Resonance (BMR) downhole survey is used to refine the hydraulic parameters of structures that intercept the future pit walls.
- Establish robust stormwater management around the pit to prevent flooding during high-intensity rainfall events.
- Update the numerical model with the additional information obtained from the recommendations.

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ABBREVIATIONS

BFS	Bankable Feasibility Study
CDT	Constant Discharge Test
Craton	Craton Mining and Exploration
ECC	Environmental Compliance Consultancy
ERT	Electrical Resistivity Tomography
ESIA	Environmental And Social Impact Assessment
HLP	Heap Leach Pad
K	Hydraulic Conductivity
KP	Knight Piésold
L	Litres
m	Metres
m/day	Metres per day
m/s	Metres per second
m^2/day	Metres squared per day
m^3/hr	Cubic metres per hour
mbc	Metres below collar
mbs	Metres below the surface
OW	Observation Well
PW	Pumping Well
T	Transmissivity

1. INTRODUCTION

Craton Mining and Exploration (Pty) Ltd is completing a Bankable Feasibility Study for the Omitiomire Copper Mine Project in central Namibia. The project comprises an open pit, waste rock dump, heap leach pad and processing plant to accommodate the planned copper mining operation. Knight Piésold Consulting was appointed to complete a hydrogeology specialist study.

The study includes assessing the proposed project's potential impacts on the groundwater, including river diversion, heap leach pad (HLP), waste rock dumps (WRD), and open pits.

1.1 BACKGROUND

The project was developed by Craton Mining and Exploration (Craton), the Namibian registered subsidiary of Omico Copper Limited, which the Australian-based International Base Metals Limited partly owns. Craton holds a mining license (ML 197) over farm Omitiomire, where exploration has been ongoing since 2007.

A pre-feasibility study (PFS) was completed for the mining project, and Craton is now looking to advance to a bankable feasibility study (BFS). The hydrogeology specialist study consists of a two-phased approach for optimising the river diversion of the Black Nossob around the open pit and the impact of the mining operations on the groundwater as follows:

- Phase 1 - Desktop data collection, documentation review, and conceptual model
- Phase 2 - Site visit, field investigations and testing, numerical model, and impact assessment updates per ECC requirements and BFS level.

1.2 OBJECTIVES

The objectives of groundwater studies are as follows:

- Characterise the site hydrogeological condition from field investigation/field data,
- Asses the groundwater impact of the proposed river diversion on the Nossob River and vice versa,
- Provide groundwater inflows to the pit and potential groundwater stresses,
- Identify risks and opportunities with mitigations to minimise risks for the BFS and future stages of the operations.

2.0 PROJECT DESCRIPTION

2.1 SITE DESCRIPTION

The proposed Omitiomire Copper Mine is located within the upper Black Nossob River catchment, approximately 140 km northeast of Windhoek, Namibia. The area is dominated by farming activity. Small settlements near the project include Steinhausen, 30km to the east; Hochveld, 40 km to the north-northwest; and Omitara, some 50 km to the south.

The site location with the proposed infrastructure for the Omitiomire mine is shown in Figure 2-1. The proposed infrastructure includes:

- An open pit.
- Waste rock dump (WRD).
- Heap Leach pad (HLP).
- Plant site and mine offices.
- River diversion.
- Road diversion

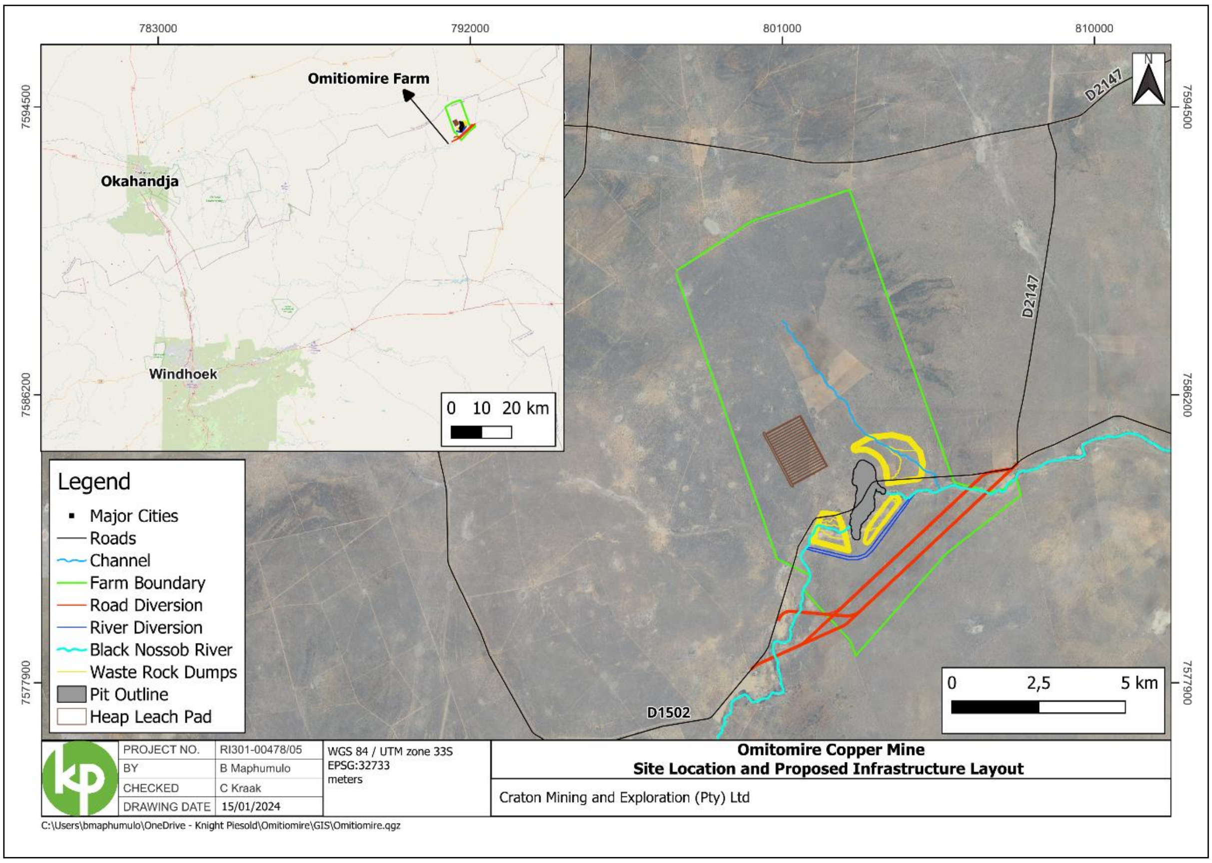


Figure 2-1: Omitiomire Site Location

2.2 TOPOGRAPHY

Most of the study area is flat without distinct topographical features. The topographical elevations within the study area vary between 1680 mamsl and 1700 mamsl on the northern border, between 1660 mamsl and 1680 mamsl on the southern border and around 1660 mamsl along the river.

The project area lies close to the surface water divide between the Okavango and the Orange-Fish River basin, in an elevated region trending north-eastwards from Khama's Hochveld, northeast of Windhoek. The ephemeral Black Nossob River flows in an eastward direction, cutting the southern end of the Groot Omitiomire farm. The river makes a wide sweeping arc heading south past Gobabis to join the White Nossob River. Numerous small tributaries contribute to the overall surface-groundwater flow of the Black Nossob River.

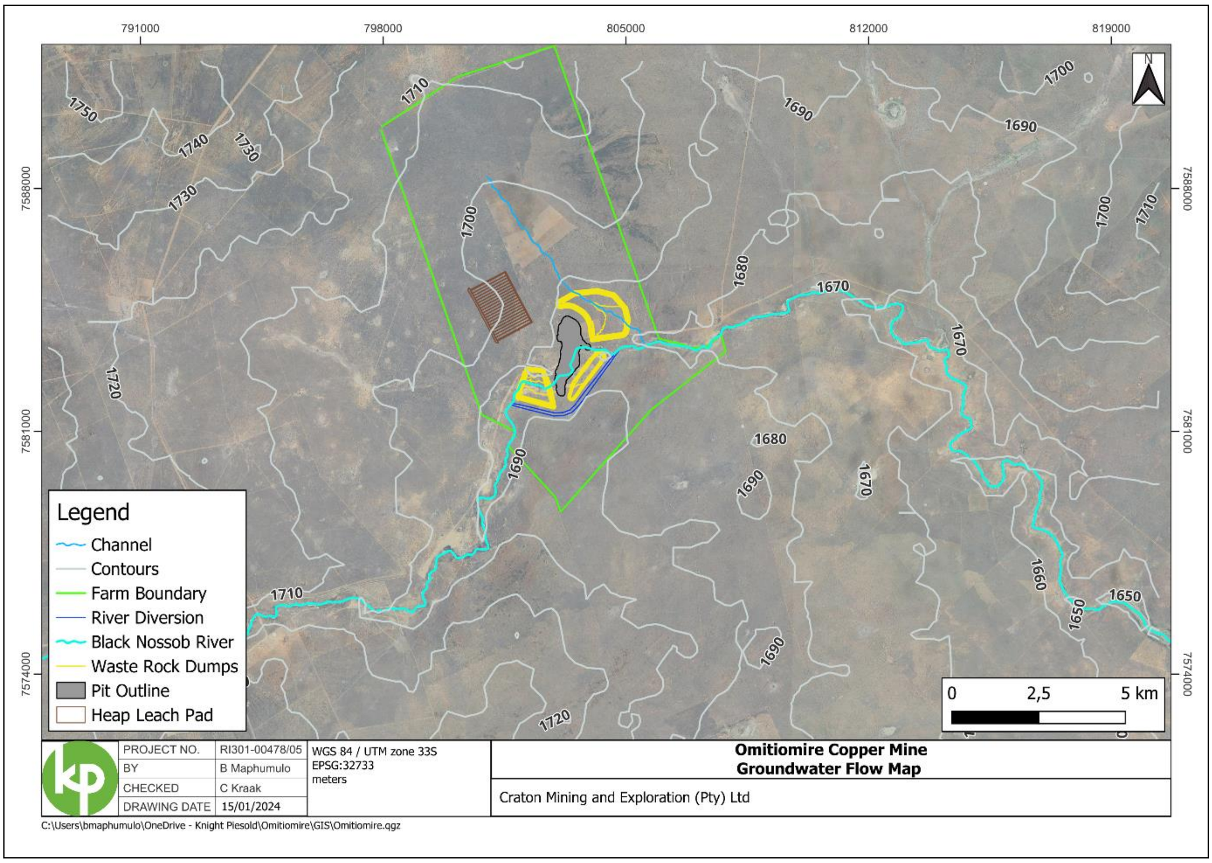


Figure 2-2: Omitiomire Topographical Map

3.0 METEOROLOGICAL INFORMATION

3.1 CLIMATE

3.1.1 TEMPERATURE

Local climate information from 1981 to 2022 was also retrieved from the USGS Earth Resources Observation and Science (EROS) Centre for this study. The parameters considered in the current climate assessment are maximum and minimum temperatures. The highest temperatures are recorded during the wet summer seasons, with the lowest during the dry winter seasons (Figure 3-1).

3.1.2 RAINFALL

As with most of Namibia, the rainfall in the project area is characterised by extreme spatial and temporal variability (Namib Hydrosearch CC, May 2008). Rainfall data for the site has been compiled from several local weather stations. The nearest weather station to the site is the Waaihoek Weather Station. Figure 3-1 shows the annual rainfall as an average from records obtained from the Waaihoek (1991 to 1998) and Otjikunda Weather Stations (1966 to 2012). The mean annual precipitation (MAP) on-site from 2008 to 2011 is 508 mm, but it is more likely that the MAP in the longer term is less and close to the catchment MAP from 400 to 450 mm.

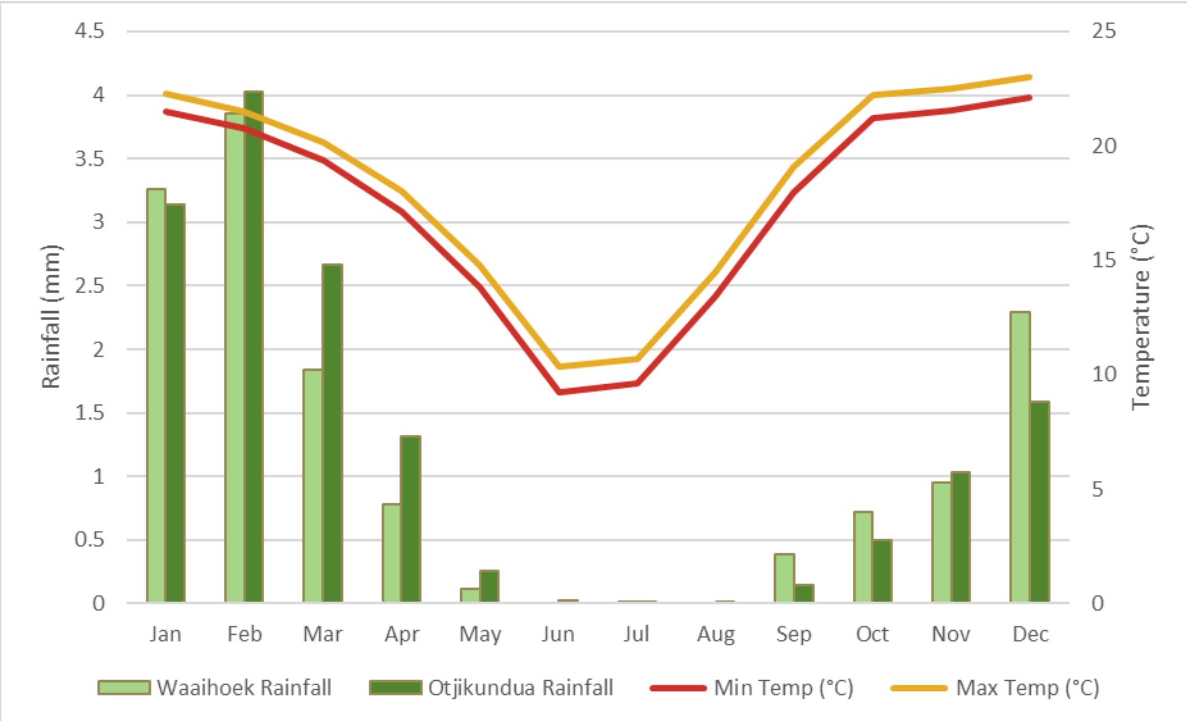


Figure 3-1: Monthly Average Rainfall (Waaihoek Weather Station (1991 – 1998) and Otjikundua Weather Station (1966 – 2012)) and Temperature Readings (EROS centre).

3.1.3 EVAPOTRANSPIRATION

Namibia is the most arid country in the Southern African regions and is predominantly characterised by minimal rainfall, periodic droughts and high annual evaporation rates of 2100 mm/year (Shikangalah & Mapani, 2019).

Figure 3-2 illustrates the monthly regional evapotranspiration rates over the 2012 to 2024 period obtained from the USGS Earth Resources Observation and Science (EROS) Centre for the Khomas Region. The monthly evapotranspiration rates vary between decadal (10-day) readings of 3 to 30 mm over the selected period. High Evapotranspiration occurs during the summer months, peaking in March, and low values during winter.

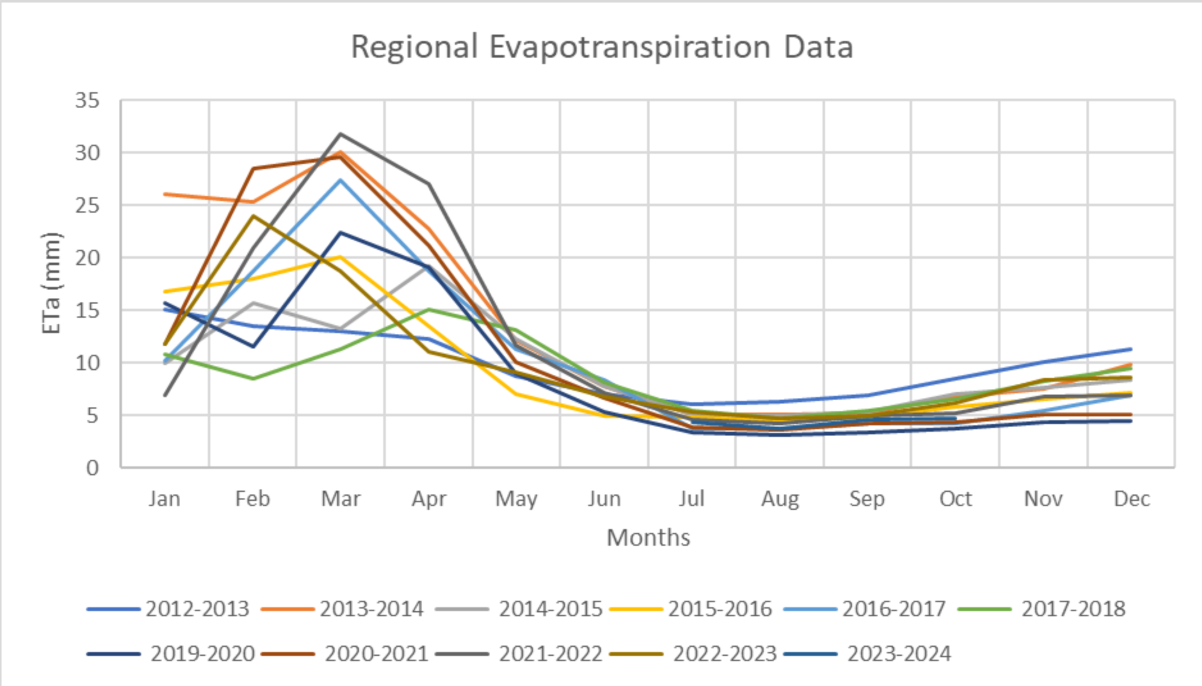


Figure 3-2: Regional Evapotranspiration Graph of Khomas Region (EROS 2012 – 2024)

3.2 CATCHMENT

The Project site is located approximately 140 km northeast of Windhoek near Steinhausen at the northeastern boundary of the Khomas Region with geographical coordinates 21°49'4.62"S and 17°58'48.45"E. Using geospatial information systems (GIS), the associated catchment boundaries were delineated, and selected catchment characteristics were determined. The Copernicus 30-metre DEM (2019 dataset) was used as it provided a reasonable estimate of the catchment flow concentrations in place of more accurate topographic survey data. KP compiled a comprehensive Surface Water Study report (Knight Piesold Consulting, 2023) [KP, WI301-00478/05 Rev B]. Details of the catchment size and longest flow paths are presented in Figure 3-3, which were extracted from the Surface Water Study report. Table 3-1 provides a summary of the essential data of the catchment.

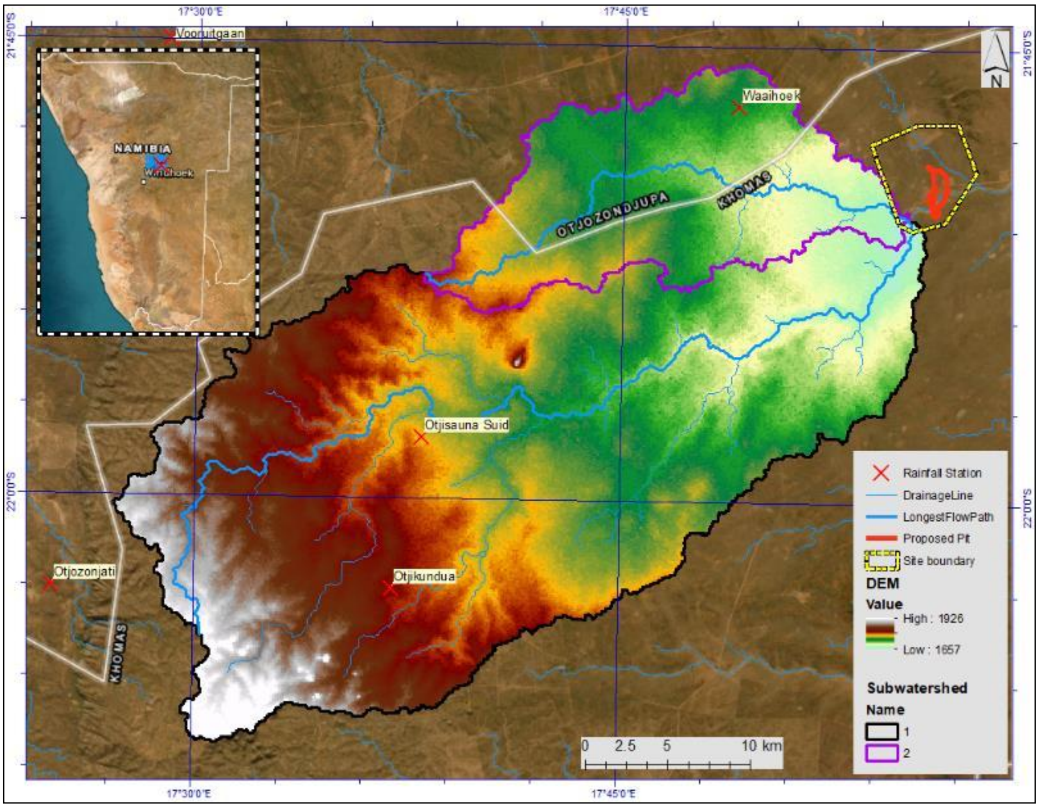


Figure 3-3: Site location, catchment areas and longest flow paths.

Table 3-1: Catchment characteristics

Parameter	Sub-catchment					
	1	2	1+2	3	4	5
Size of the catchment (km^2)	880	239	1119	96.6	11.3	3.5
Longest flow path (km)	81.7	41.7	81.7	22.8	9.5	3.8
Longest Watercourse Slope 10-85 (m/m)	0.0019	0.002	0.0019	0.0023	0.0031	0.0056
Defined watercourse time concentration (hrs)	23	12.7	23	7.4	3.8	1.9

4.0 SITE WORK

The fieldwork for this investigation was undertaken in April 2023. Details of the report can be found in Appendix 1 and are summarised below.

4.1 GEOPHYSICS

An Electrical Resistivity Tomography (ERT) geophysical survey was conducted by Greg Symons Geophysics to characterise subsurface geological conditions and determine the depth of overburden and presence of geological structures, i.e., faults and dykes. A structural interpretation of the area was undertaken based on regional aeromagnetic data, and 13 lines were delineated for subsequent ERT surveys (Figure 4 1). The maximum depth of penetration for the ERT geophysical survey was 50 m.

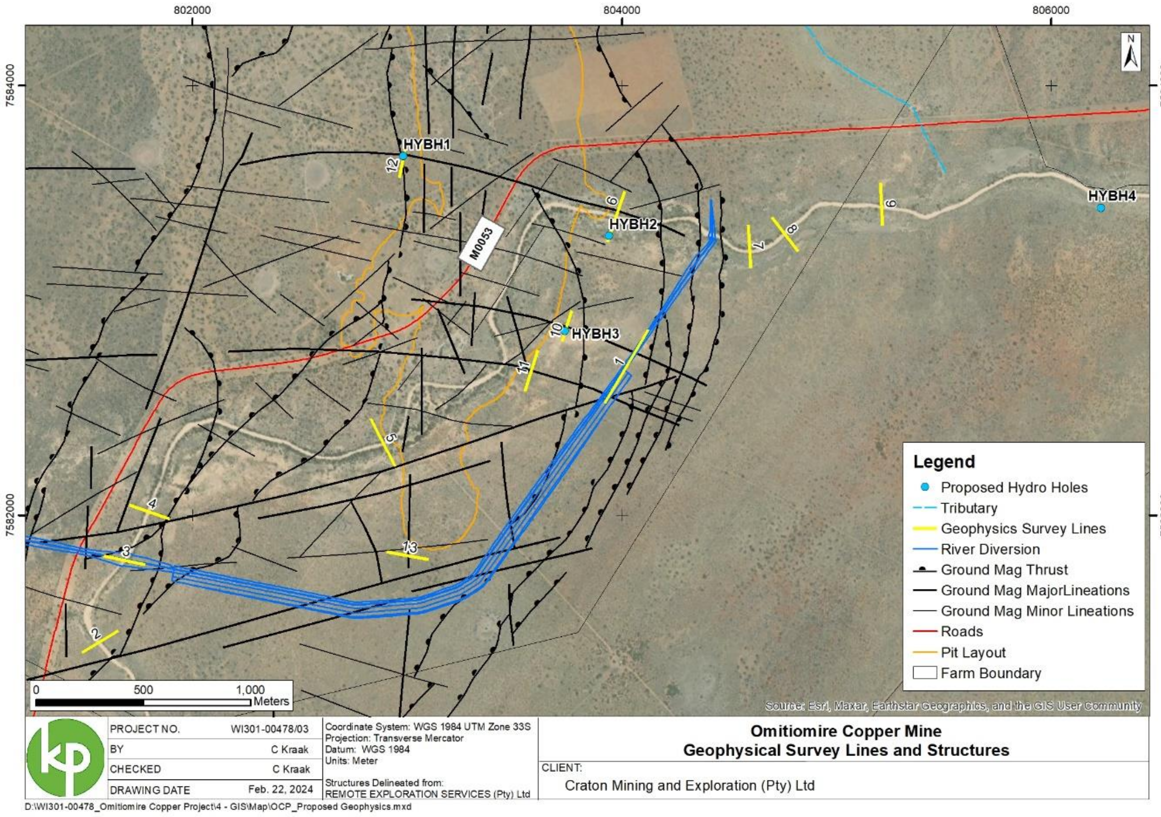


Figure 4-1: Geophysical Survey Lines Over Delineated Structures.

An example of the inverted resistivity depth sections generated following the interpretation of the data is provided, showing the section for Survey Line 5 located on the Black Nossob River at the southwestern western edge of the proposed pit. The complete geophysical report with the remaining sections is provided in the KP Field Report, Appendix A.

Interpretation of the survey data indicates the following near-surface stratigraphy:

- A total of 3 overburden layers were observed. This stratigraphy is defined as
  - (Area a) a top, sandy, resistive layer.
  - (Area b) a conductive clay-bearing layer, and
  - (Area c) a deeper resistive sandy layer.

- Below the overburden, a weathered conductive basement was observed (Area d). The weathered basement changes at depth to resistive fresh rock.
- The conductive overburden layer is likely associated with the quaternary-aged units associated with the Black Nossob River. It could be related to flood events where the river has flooded its banks and deposited clay-dominant lithologies on the flood plain.
- Overburden may be related to windblown Kalahari-aged sediments with no evidence of faulting propagating through this unit.
- Vertical faulting in an N/S and E/W direction is related to Cretaceous and late Karoo tectonics, which appears to be detected by the resistivity as conductive water-bearing faults and fractures.

Several coordinates were provided for potential faults and were used to target drilling locations to intercept the faults at a depth below the expected groundwater level (Figure 4-1).

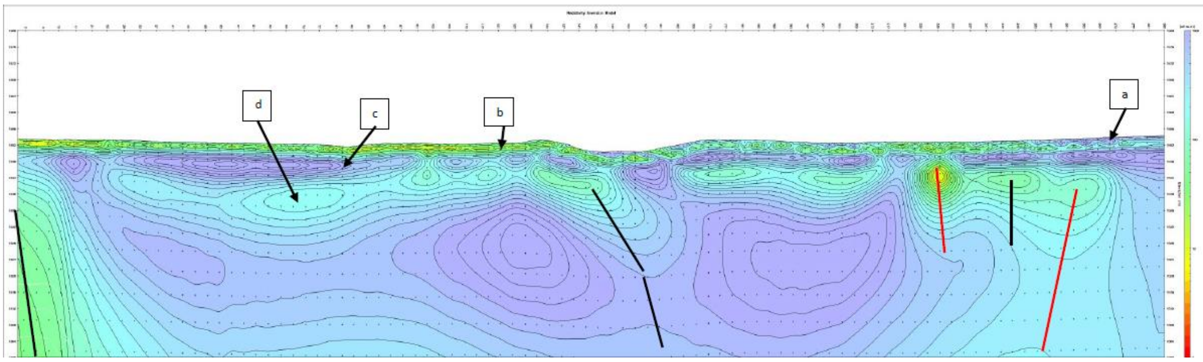


Figure 4-2: ERT Line 5 (Adams & Symons, 2023)

4.2 GROUNDWATER EXPLORATION BOREHOLES

Four groundwater monitoring boreholes were sited and drilled at the Omitiomire site with the chosen borehole location based on the geophysical survey results. The flow rates and blow yields were measured when a water strike was intercepted.

A KP Site Hydrogeologist undertook drilling supervision, chip logging, and photography according to the provided Standard Operating Procedure. The boreholes were primarily drilled at a ten-inch diameter for roughly the first 20 m until the weathered zone was surpassed. Once fresh rock was intercepted, the borehole was completed at an eight-inch diameter. The borehole logs and construction details are presented in Appendix C in the comprehensive field report (Knight Piesold Consulting, 2023) [KP, Ref RI23-00286]. A summary of the drilling undertaken is presented in Table 4-1.

Table 4-1 Borehole Summary

BoreholeID	Coordinates (UTM 33S)		Dates drilled	Borehole Depth (mbs)	Water Strike (mbs)	Blow Yield (m^3/hr)
	X-UTM33S	Y-UTM33S				
HYBH01	802982	7583671	19th to 22nd April 2023	120	32 to 33	1.5
HYBH02	803941	75833299	28th to 29th April 2023	100	-	-
HYBH03	803735	7582856	24th to 25th April 2023	100	40	4.5
HYBH04	806231	7583430	1st to 2nd May 2023	110	92 to 93	5.3

4.3 HYDROCENSUS

4.3.1 ECC MONITORING

ECC conducts monthly water level measurements and quarterly water quality monitoring of various boreholes within the site area. A map showing the location of the boreholes and water elevations recorded in June 2023 is presented in Figure 4-3. A tabulated form of the water levels is given in the KP Field Report (Appendix D1).

4.3.2 KP HYDROCENSUS

A local hydrocensus was carried out by KP and included water level measurements, noting the condition of the boreholes, obtaining information on the privately owned boreholes, and identification of other groundwater-related features within the mine area. It is advised that borehole OR 719 from the KP hydrocensus and WW202122 from the ECC monitoring program are the same borehole.

Water levels in the area typically range from 15 to 29 meters below surface (mbs), with water level in the northwest of the site shallower (closer to the watershed and catchment boundary). Water levels in the deeper aquifer decrease towards the south, although they appear shallower along the river channel. Borehole ORC 606 has the deepest water level (62.37 mbs), and BH05-SWD has the shallowest (2.54 mbs).

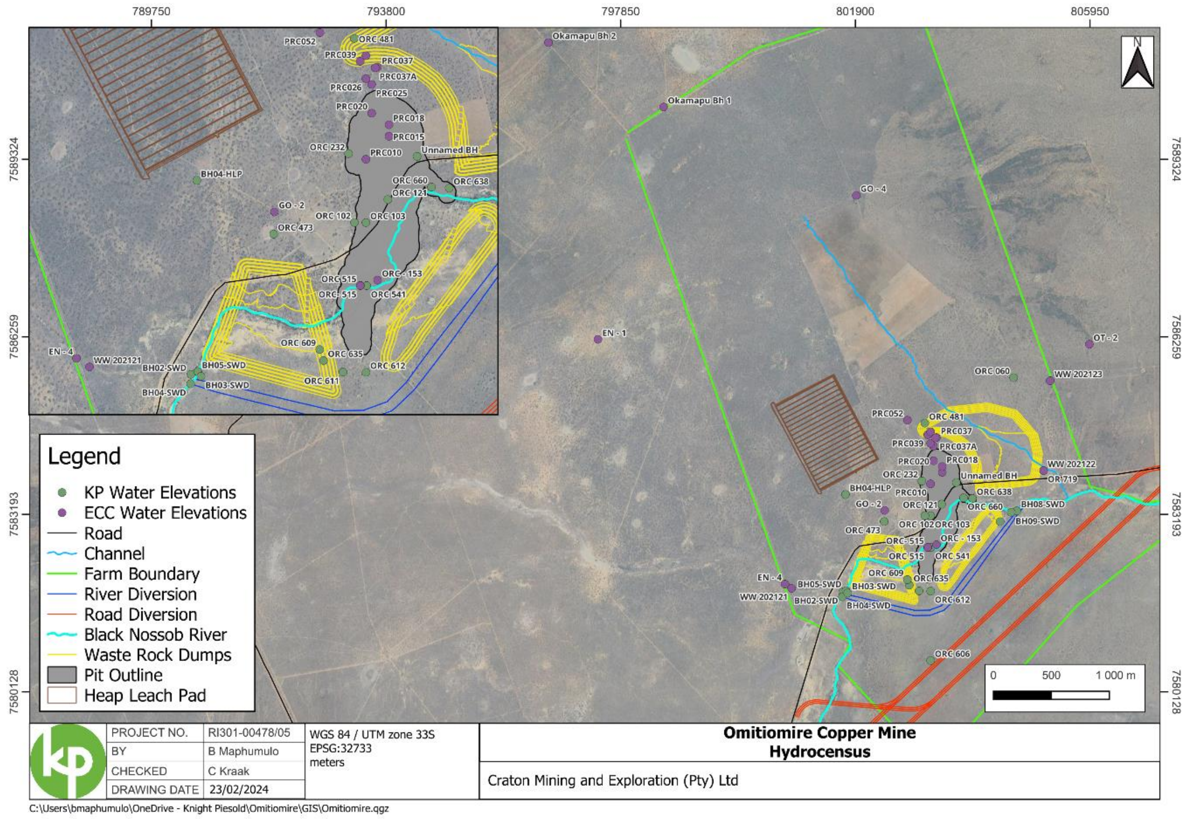


Figure 4-3: Boreholes identified during the KP and ECC Hydrocensus.

4.4 AQUIFER TESTS

Aquifer tests were conducted per the Omitiomire Test Pumping SOP (KP Field Report 2023, Appendix B) on multiple boreholes within the project area. Testing included:

- Slug tests.
- Falling head tests.
- Step tests and constant discharge pumping tests.

The purpose of aquifer testing is to stress the aquifer(s) sufficiently, and based upon the drawdown and recovery data of the water level to:

- Estimate aquifer properties (e.g. hydraulic conductivity, transmissivity, storage).
- Identify aquifer boundaries (e.g. recharge and discharge zones).

Figure 4-4 indicates the location of boreholes where aquifer testing was undertaken with the type of test performed.

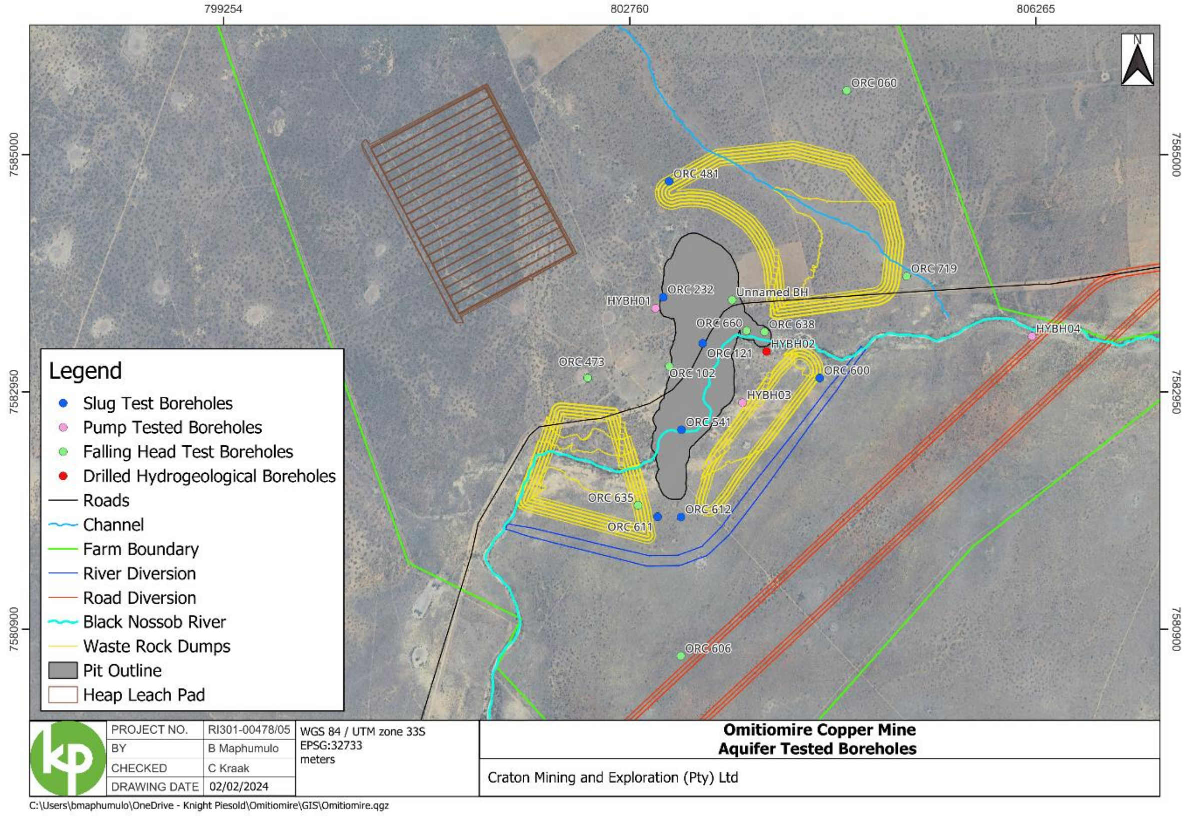


Figure 4-4: Aquifer Tested Boreholes

4.4.1 FALLING HEAD TESTS

During the falling head tests, a specified volume of water is introduced into a borehole to displace the static water level. The water level and time to recover to the static level are then monitored, which is used to determine the hydraulic conductivity (K). The tests were conducted on several boreholes in the pit and waste rock dump areas. The data was analysed using the Bouwer-Rice method and the AQTESOLV software (See the KP Field Report 2023, Appendix E1). The field report includes AQTESOLV plots; the results are summarised in Table 4-2.

Table 4-2: Summary of Falling Head Tests

Borehole ID	Coordinates		Volume of Water Added (L)	K (m/day)	Transmissivity (m^2/day)	Saturated Thickness (m)
	X - UTM 33S	Y - UTM 33S				
ORC 121	803380	7583370	1 000	0.051	7.65	150
ORC 473	802398	7583071	1 000	0.017	2.01	121
ORC 102	803101	7583171	~250	0.070	8.47	1121
Unnamed BH	803644	7583745	1 000	0.046	5.57	121
ORC 635	802831	7581972	~850	0.027	5.4	200
OR 719	805150	7583950	1 000	0.065	4.33	67
ORC 638	803923	7583469	~250	0.010	1.21	121
ORC 660	803769	7583479	~800	0.011	1.33	121
ORC 060	804633	7583469	1 000	0.036	4.36	121
ORC 606	803201	7580670	1 000	0.048	1.92	40

Transmissivity (T) values shown in Table 4-2 were calculated using the formula below adapted from (Ward, 1967)

$$T = Kb$$

Where:

- T = Transmissivity (m^2/day)
- K = Hydraulic conductivity (m/day)
- b = aquifer thickness (m)

4.4.2 SLUG TESTS

Slug tests were conducted by inserting a slug into the borehole to displace the water level and monitoring the time the water level takes to recover. The slug consists of 3 compartments and is 2.435 kg in mass with a volume of 0.0009 m^3. The AQTESOLV plots are also in the 2023 KP Field Report, Appendix E2. A summary of the results is shown in Table 4-3.

Table 4-3: Information Summary on Slug Test Performed

Borehole ID	Geology	Coordinates		Water Level (mbs)	K (m/day)	Transmissivity (m^2/day)	Saturated Thickness (m)
		X - UTM 33S	Y - UTM 33S				
ORC 541	gneiss	803206	7582623	16.49	0.0048	0.58	121
ORC 611	gneiss	803001	7581872	27.49	0.007	1.26	180
ORC 232	gneiss	803049	7583769	22.52	0.22	26.40	120
ORC 204	gneiss	803499	7583669	18.38	0.045	5.45	121
ORC 481	gneiss	803100	7584769	18.95	0.0044	0.53	121
ORC 612	gneiss	803201	7581869	26.45	0.0051	0.62	121

Transmissivity (T) values shown in Table 4-3 were calculated using the formula below adapted from (Ward, 1967)

4.4.3 PUMPING TESTS

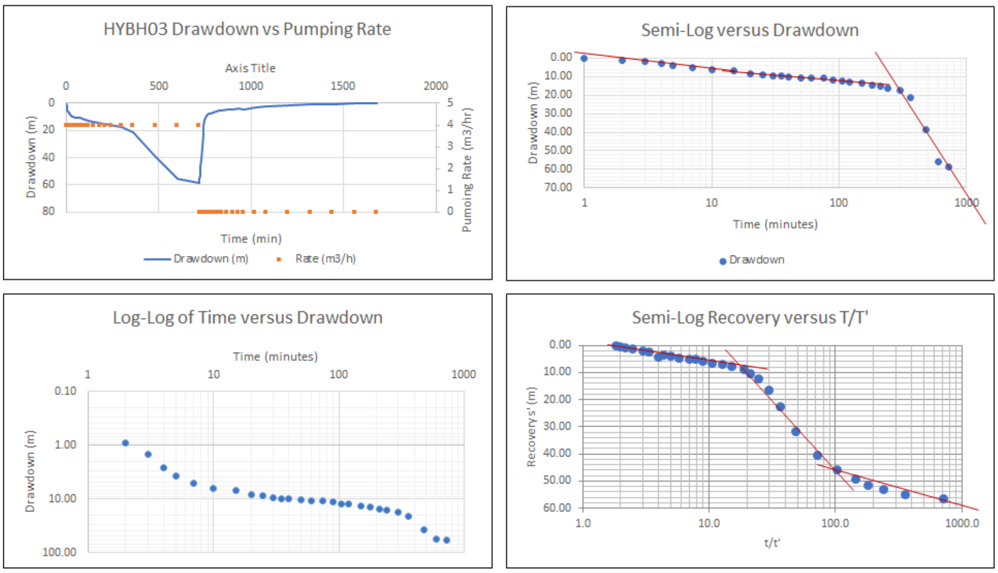
Pumping tests were undertaken from 05th June to 17th June 2023 at HYBH01, HYBH03 and HYBH04 boreholes. The procedure included four 1-hour step-test (2023 KP Field Report, Appendix E3) at increasingly higher discharge rates to determine the optimum rate for the subsequent constant discharge test (CDT).

The data analysis included straight-line Cooper Jacob plots (completed in Microsoft Excel for drawdown and curve matching, 2023 KP Field Report, Appendix E4) and were further analysed in AQTESOLV. The plots can be found in Appendix E5 in the field report. The summary of the CDT can be seen in Table 4-4. The CDTs were carried out for 12 hours. The available drawdown was determined by subtracting the depth of the pump inlet from the static water level measured in the borehole.

Table 4-4: Summary of Constant Discharge Test

Borehole ID	Depth (mbs)	Available drawdown (mbs)	Pumping Rate (m^3/hr)	Drawdown (mbs)
HYBH01	120	80.4	2	49.1
HYBH03	100	67.55	4	58.75
HYBH04	110	72.2	1.2	40.05

All three borehole pumping results exhibited time-drawdown relationships typical of pumping from a densely fractured, highly permeable fault of infinite length and finite width in an otherwise confined, homogeneous, isotropic, consolidated aquifer of low hydraulic conductivity and high storage capacity (Kruseman and de Ridder, 2000). Figure 4-5 shows HYBH03 as an example of this data, and it also shows that during pumping, an aquifer boundary was reached near the end of the pumping test, indicating a lower hydraulic conductivity by an order of magnitude for the rock matrix.



Pumping		
Q	96	m^3/day
b	80.55	m
Δ s Early	6.3	m
Δ s Mid	5.9	m
Δ s Late	70	m
T Early	2.78	m^2/day
T Mid	2.97	
T Late	0.25	m^2/day
K Early	0.03	m/day
K Mid	0.03	
K Late	0.003	m/day

Recovery		
Q	96	m^3/day
b	80.55	m
Δ s Early	13.8	m
Δ s Mid	13.3	
Δ s Late	6.7	m
T Early	1.27	m^2/day
T Mid	1.32	
T Late	2.62	m^2/day
K Early	0.01	m/day
K Mid	0.01	
K Late	0.03	m/day

Figure 4-5: Cooper-Jacob plots for pumping borehole HYBH03.

The data obtained from the aquifer tests are indicated on the hydraulic conductivity graph (Figure 4-6), showing that the fractured aquifer falls within the intermediate permeability range, which is in the range for fractured igneous and metamorphic rocks (Freeze & Cherry, 1979).

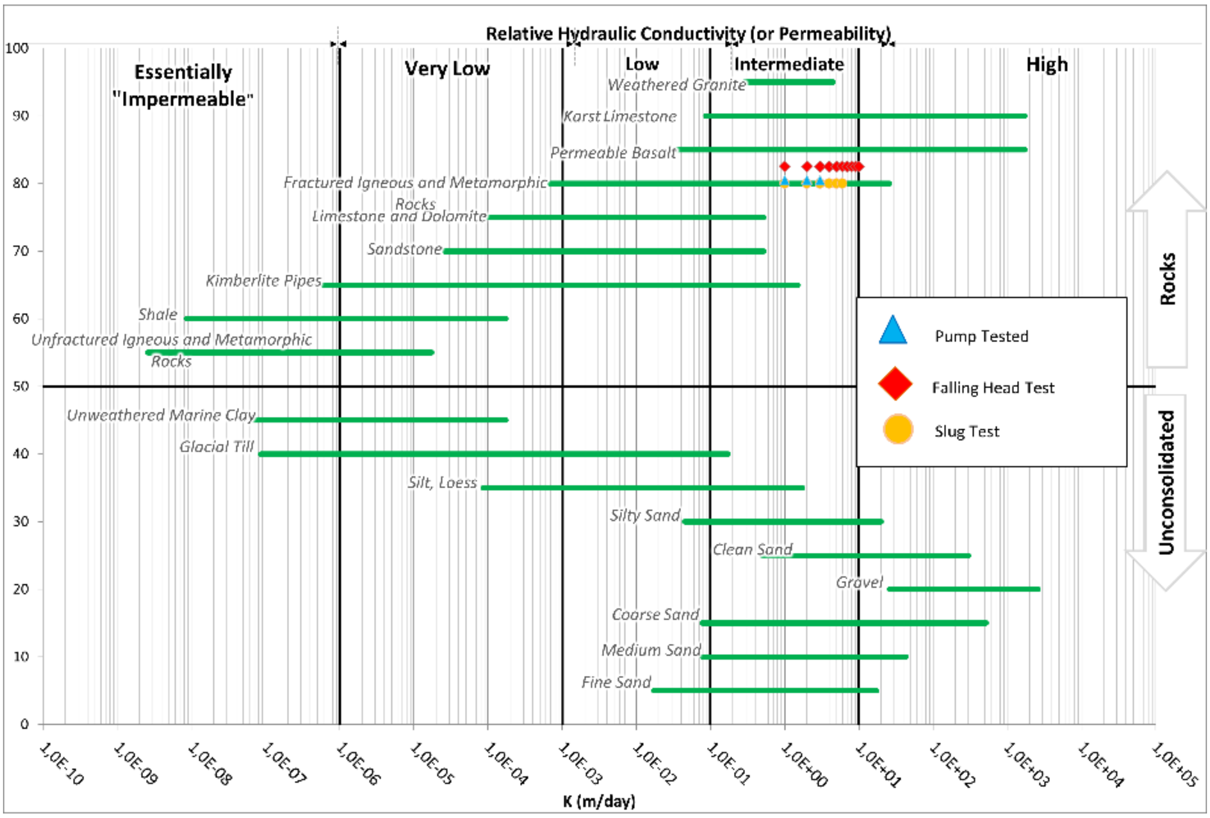


Figure 4-6: Hydraulic Conductivities of Aquifer Tested Boreholes

5.0 GEOLOGY

5.1 SOIL

In 2013, SRK conducted a geotechnical investigation. The investigation revealed that much of the project area is covered by a thin layer of reddish-brown micaceous silty sand, which is assumed to be aeolian Kalahari sands. It was also observed that regions near the Black Nossob River are underlain by lighter-coloured alluvial soils, typically fine to medium-grained alluvial sands with some quartz gravel. The Kalahari sands overlay a pedogenic hardpan calcrete horizon in some areas where conditions are favourable. These conditions were commonly noted in depressions in the local topography where water accumulates, and water levels continually fluctuate within the soil horizon. (SRK, 2013).

KP conducted a geotechnical investigation from March to May 2023 to determine feasibility. The locations of the test pits and boreholes used during the study are displayed in Figure 5-1.

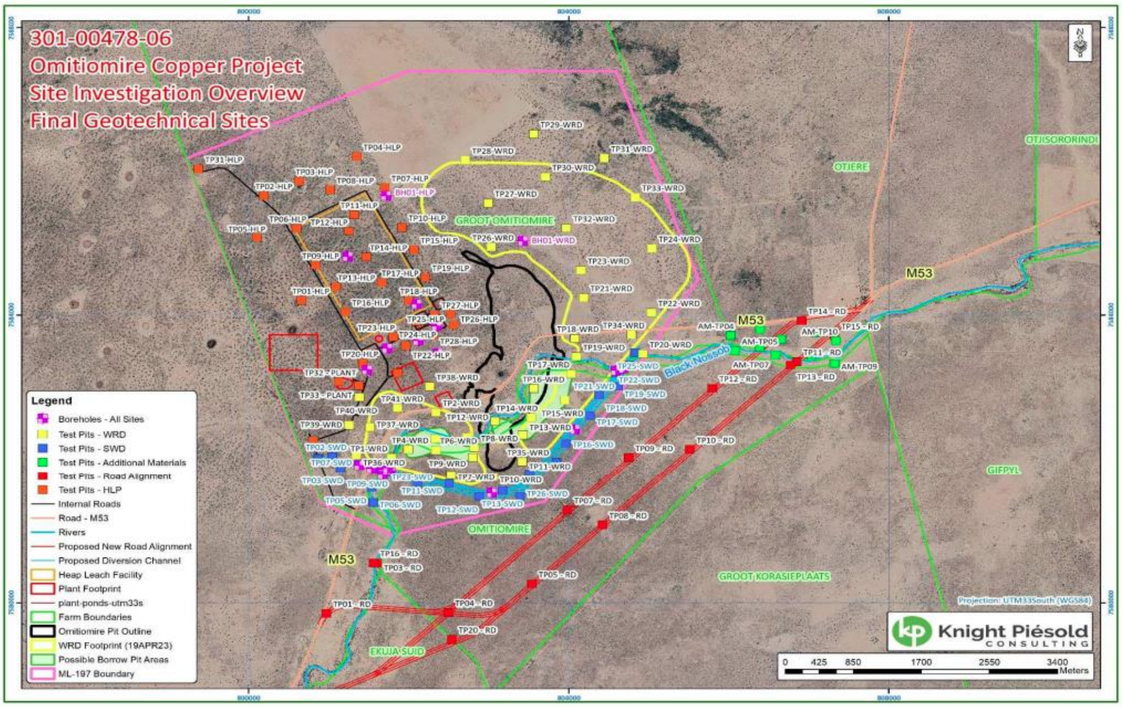


Figure 5-1: Overview of Geotechnical Test Pits and Boreholes

The geotechnical investigation indicates that elluvium soils cover the site boundary, forming a thin layer. This layer varies in thickness from 0.3 to 2.3 meters. The soils are generally described as loose to medium dense, dry to slightly moist, and brown to dark brown silty sand, with voids for roots.

The soils formed by the natural processes of soil development, known as pedogenic soils, are mainly composed of calcified alluvium, with occasional occurrences of calcareous, ferruginous, and ferruginised alluvium. The depth of these soils varies across the site, ranging from 0.3 to 4.0 meters. Excavator refusal is typically encountered at around 1.5 meters in ferruginised alluvium.

The residual gneiss is typically found at depths between 1.4 and 6.8 meters across the site. It is generally 0.3 to 0.5 meters thick and consists of reddish-brown to light brown, medium dense to dense, silty sandy gravel. The residual soil becomes very dense with depth towards the bedrock. The depth to bedrock across the site is shallow, with soft to medium hard rock encountered from about 1.5 meters.

Gneiss bedrock is usually found within 5 meters from the surface as soft rock, which becomes medium-hard to hard rock as it gets deeper due to weathered joints or mafic bands. If the depth exceeds 6 meters, medium hard rock gneiss or harder is typically encountered.

5.2 SITE GEOLOGY

The dominant geological feature at Omitiomire is the metamorphosed Ekuja Basement Dome, which comprises millimetre to ten-metre scale alternating felsic, amphibolite and amphibole-biotite schist. The local site geology is shown in Figure 5-2 below. According to the generalised geological map of Namibia, the underlying pre-Damara lithologies are flanked by the Swakop lithologies of the Damara sequence. The lower Mokolian age foliated rocks of the Hohewarte Metamorphic Complex underlie Kalahari Group sediments. Surrounding the Hohewarte Complex are the lower Swakop Group rocks, dominantly mica schist and amphibolites. Kuiseb formation rocks (mica schist, amphibolite, quartzite, and graphite schist) are present to the south. To the north, Swakop and Nossib group rocks underlie thicker Kalahari Group Sediments (Namib Hydrosearch CC, 2008).

The Omitiomire Copper Deposits are hosted in a sequence of gneiss, schist, and amphibolite, which form a dome structure (the Ekuja Dome) which covers an area of approximately 15 km x 12 km (Omico Mining Corporation, 2022). Based on studies conducted by SLR (2013), copper mineralisation occurs mainly as chalcocite, which is preferentially concentrated in bands of biotite-bearing schist, either in dark biotite schist, finely banded quartz–plagioclase – biotite hornblende schist, or in epidote-bearing schist. The epidote-bearing schist contains the highest copper concentration. Chlorite, sphene, K-feldspar, and magnetite are minor components of the mineralised zone. The deposit is a tabular copper deposit, striking north-south and dipping at a shallow angle (around 20° to 30°) to the east. The deposit is approximately 10 m thick near the surface but thickens to the east, where some exploration drill holes have intersected over 100 m of copper mineralisation. The near-surface expression of deposits has been oxidised by weathering.

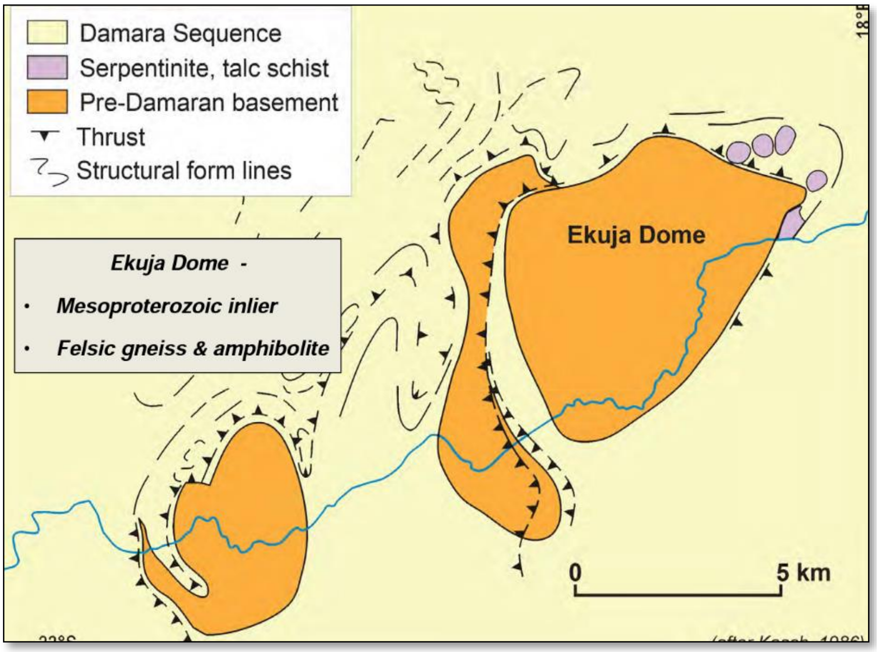


Figure 5-2 Regional Geological Setting of the Omitiomire Project (International Base Metals Limited, 2014)

5.3 STRUCTURAL GEOLOGY

The area has undergone significant metamorphism and structural evolution, impacting the groundwater regime, as shown in Figure 5-3. Several studies have been undertaken based on a variety of geophysics.

- Two lineaments, the Okahandja Lineament in the northwest and the Kudu Lineament (Corner & Durrheim, 2018), are discernible in the regional magnetic data striking the northeast. It is evident from Figure 5-3 that these two lineaments form important geological boundaries, with the area between them displaying a different magnetic fabric (Steinhaussen Licence Block, 2009).
- A fracture traces mapped plan by Namib Hydrosearch using aeromagnetic data by Corner Geophysics (Corner Geophysics, date unknown) and Landsat ETM+ images showed dominant NE and WNW fracture directions. The NE trending fracture direction coincides with the regional strike of Damara Supergroup rocks and lithological contacts of the lower Swakop Group rocks. Therefore, parallel fractures are important groundwater targets, particularly along drainage courses (Namib Hydrosearch CC, 2008).
- An array of east-west trending structures was identified (Ground Magnetics for Omitiomire, 2009) and are believed to have significant control on the groundwater regime based on the angular flow of the Black Nossob River.

The conclusion from these studies is a consensus that the structures in the region influence the groundwater flow.

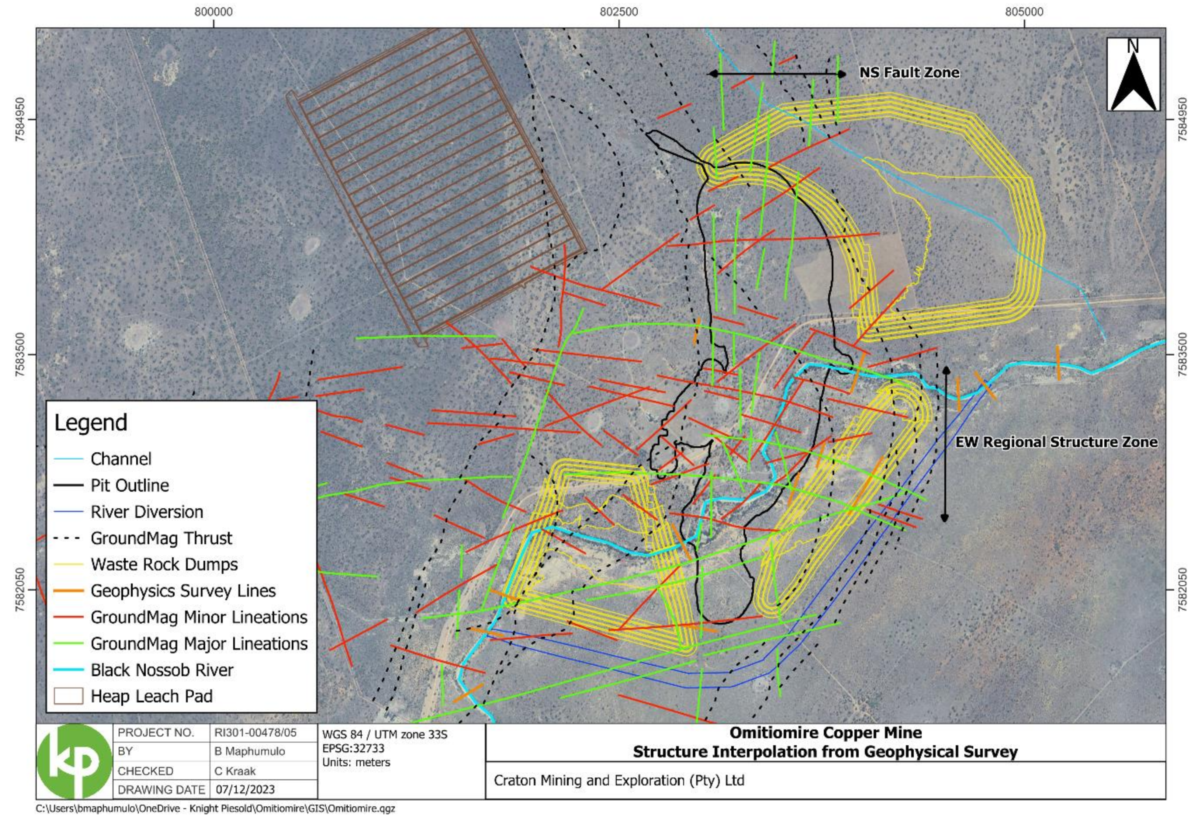


Figure 5-3 Structure interpolation from Ground Magnetic Geophysical Survey

6.0 HYDROGEOLOGY

6.1 AQUIFERS

The hydrogeology of the region is primarily characterised by fractured aquifers found in the foliated gneisses, amphibolites, and schists. These units are underneath the Kalahari Group sediments, residual soils, and weathered rock units. In this area, shallow perched aquifers occur due to calcrete lenses, which result in the development of pans. The primary aquifer that provides water to local farmers are the alluvial deposits and the deeper weathering profile associated with the Black Nossob River.

The hydrogeological characteristics are discussed in reports compiled by (SLR Consulting, 2013) and (Beak Consultants GmbH, 2012). Several different hydrostratigraphic units were identified in the study area (Table 6-1).

Table 6-1: Summary of hydrogeologic units (After (SLR Consulting, 2013))

Formation	Rock Type	Aquifer Type	Conditions	K (m/day)
Alluvial deposits of the Black Nossob River and its tributaries	Silty sand, gravel	Porous	Unconfined	0.4 - 1
Weathered bedrock, elluvials, gravel and calcrete plains	Calcareous sand and gravel, clay and fines	Mixed	Unconfined	0.03 – 0.09
Kalahari-Formation	Sand and calcrete	Porous	Unconfined	0.1 – 0.2
Ekuja Dome	Gneiss with micaschist and pegmatite inliers	Fractured	Confined	0.001 – 0.005
Faults and lineaments	Pegmatites, breccia	Fractured	Confined	0.1 – 0.2

6.1.1 ALLUVIAL AND TRANSPORTED SEDIMENTS

The groundwater levels in the shallow alluvial aquifer are less than 15 mbs, with the general groundwater flowing in an eastern direction along the Black Nossob River. Rainfall events and occasional river flows recharge the groundwater levels. The alluvial sediment are spatially variable are comprise brown to dark brown, clayey, silty sand / sandy, silty clay with minor to traces of sub-angular to sub-rounded quartz gravel.

The porous Kalahari sediments comprise a sandy and calcrete layer. The calcrete layer consists of gravelly, sandy silt with a calcareous matrix.

6.1.2 WEATHERED

The weathered profile is highly irregular and varies according to fracture density and rock type. The gneiss rocks tend to be less weathered and hard within about 10 m from the surface, and amphibolite rocks may be distinctly weathered to a depth of 20 m or even more.

6.1.3 FRACTURED

The groundwater flow regime of the deeper regional aquifer is defined by the fissures and fractures within basement rocks. There is a notable lag in the rise in water levels after flood and rainfall events, and the fluctuation does not usually exceed more than 5 m. In the study by SLR (2013), boreholes closer to the Black Nossob River that penetrate the major fractures show an almost immediate rise in groundwater levels after rainfall events. However, little to no change was observed in boreholes further from the Black Nossob River.

6.2 GROUNDWATER LEVELS AND FLOW

While the shallow aquifer is unconfined with groundwater flow dominated by vertical flow components such as evaporation and recharge, the deeper fractured aquifer is confined and structurally controlled by fractures and faults of the basement rocks of the Ekuja Dome.

Shallow water levels (≤ 20 mbs) occur seasonally in the shallow weathered aquifer associated with the Black Nossob riverbed and its tributaries (Beak Consultants GmbH, 2012), transitioning from a losing connected river to a losing disconnected river in the drier season. The elevated groundwater levels are recharge-dependent. Groundwater levels in the deeper regional aquifer generally range from 20 to 40 mbs. Figure 6-1 shows the groundwater elevations in boreholes measured during the hydrocensus. Figure 6-2 illustrates the inferred groundwater elevation contours and general groundwater flow direction. Levels measured in the riverbed are generally higher in elevation than those measured adjacent to the river within 50 m and deepening further from the river, showing trends typically associated with losing rivers. The overall groundwater flow is in a south-easterly to easterly direction.

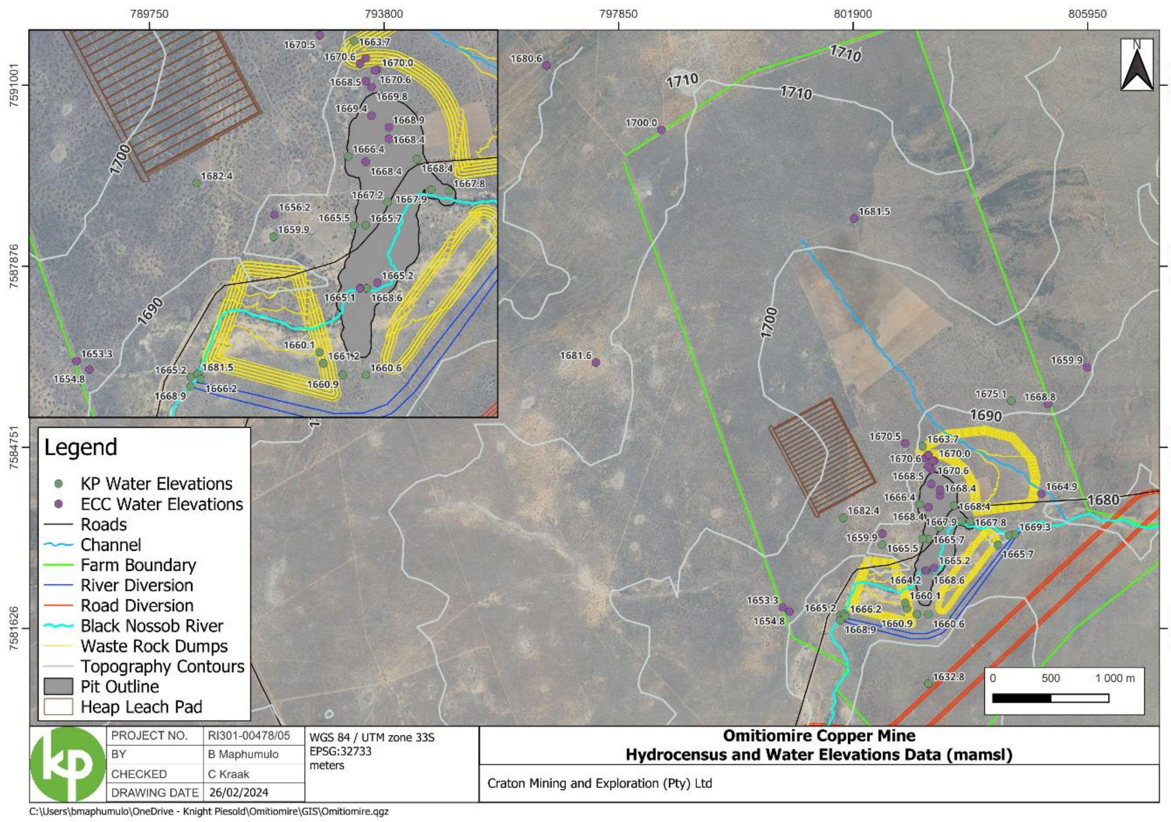


Figure 6-1: Regional Groundwater Levels at Omitiomire Area

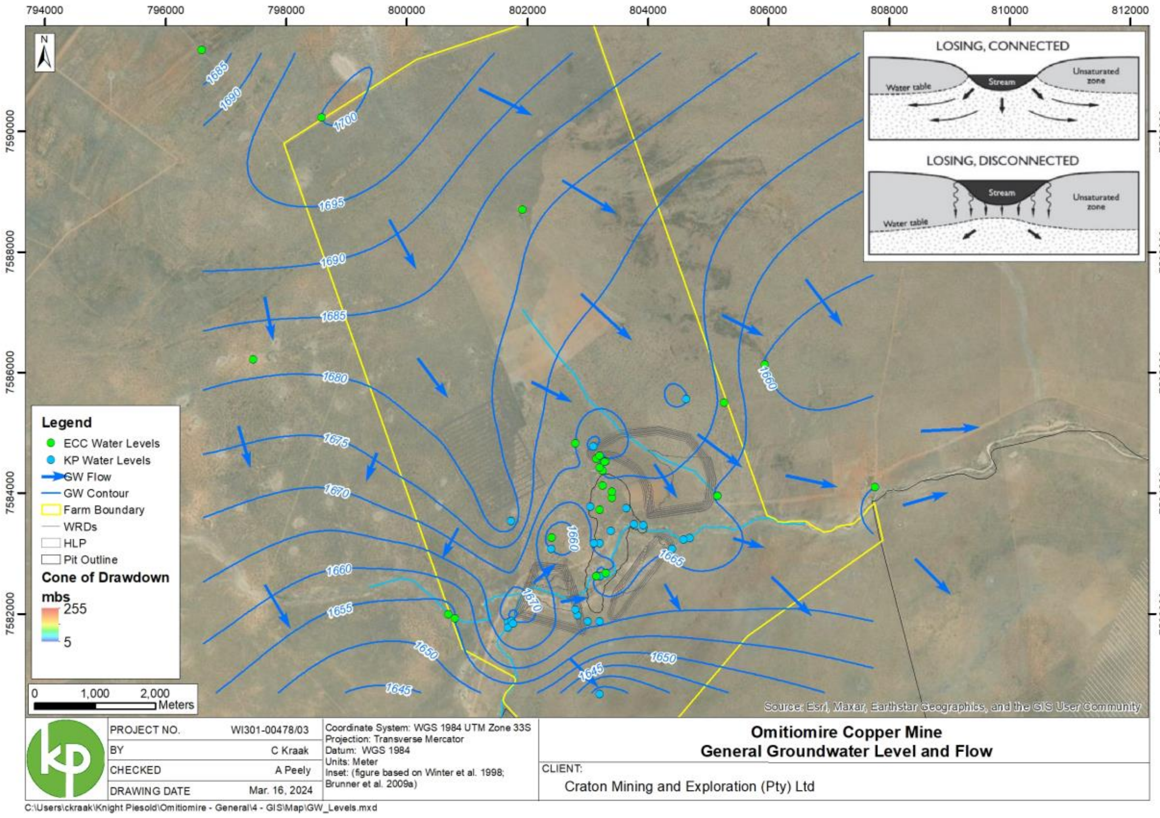


Figure 6-2: Regional Groundwater Flow

6.3 HYDROCHEMISTRY

ECC conducts quarterly monitoring at the Omitiomire site, and Aquatico, a SANAS-accredited laboratory in South Africa, analyses the water samples. KP collected water samples during the site investigation in 2023, and the samples were sent to the M & L laboratory for analysis, which is also SANAS accredited. The analysed Water quality parameters included but were not limited to pH, EC, major ions, metals, and metalloids (ICP scan). The laboratory certificates are attached in Appendix 2.

The water quality parameters were compared against the standards for comparing to the groundwater quality in the 2004 Water Act, Drinking Water Standards in Namibia and the Water Quality Standards of the Water Act, No 54 of 1956. The classifications of the designated groups are as follows:

- Group A – Acceptable
- Group B – Allowable
- Group C – Max Allowable
- Group D – Exceeding

6.3.1 GENERAL HYDROCHEMISTRY

The graphs shown in Figure 6-3 and Figure 6-4 show the concentrations of the water samples taken at each borehole. Constituents exceeding the Group A limits are highlighted in orange; the following observations were made:

- Most samples fall within Group A limits of good water quality.
- The pH range for the sampled boreholes is well within Group A limits (6-9)

- The Electrical Conductivity (EC) for all the samples ranges from 58.5 to 278 (mS/m). The elevated EC is attributed to the higher chloride (Cl) and sodium (Na) concentrations in some water samples, particularly EN-01 and OT-1.
- Na levels fall within Group A limits except for EN-01. During the March 2023 monitoring, OT-1, WW202121, and WW202120 had higher Na levels. During June 2023 monitoring, OT-1 had higher levels of Na. Additional boreholes were sampled and analysed in June 2023: the Okamapu Borehole and the newly drilled monitoring boreholes. The Okamapu Borehole and HYBH03 samples (taken before and after test pumping) had elevated concentrations of Na, which exceeded Group A limits.
- The chloride concentration for all samples falls within Group A limits except for EN-01.
- The fluoride (F) concentrations fall well within the set limits apart from GO-4. It is also noted that the first sample taken from HYBH03 had an F concentration of 1.5 mg/l, and the sample taken after pump testing was 1.47 mg/l. Felsic rocks, i.e. granite and gneisses, are often associated with higher fluoride levels.
- The nitrate (NO_3^-) concentration ranges from 0.1 to 128 mg/l. Most samples fall within group A limits except for EN-01, OT-1 and ORC-153. EN-01 is near a watering trough, so these elevated concentrations and the higher Na and Cl can be attributed to animal waste at watering points. Similarly, ORC-153 is located close to the river and several cattle tracks.
- The second sample from HYBH03 (after pump testing) had a NO_3^- concentration of 11.46 mg/l.
- All sulphate (SO_4^{2-}) concentrations fall within Group A limits except for OT-1 and OT-2. During the March 2023 monitoring, WW 202120 had slightly elevated SO_4^{2-} levels.
- Phosphate levels range from 0.008 to 0.94 mg/l. Most samples have low concentrations; however, slightly higher concentrations are found in WW202121 and ORC-515. Both boreholes are located near the Black Nossob.
- Elevated magnesium (Mg) levels are found in numerous water samples. They are likely attributed to the areas geology being dominated by metamorphic rocks (amphibolite) having minerals with high Mg content, i.e., hornblende.
- Most samples have “acceptable” water quality per the Namibian Drinking Water (NDW) standards. Water taken from borehole OT-1 is considered “allowable”, and EN-01 exceeds the limits.

Figure 6-3: pH, TDS, EC, and Cl of Analysed Samples

Figure 6-4: Na, NO_3^-, and SO_4^{2-} Trend of Analysed Samples

6.3.2 PIPER PLOT

A Piper diagram is used to classify the water samples as ratios of anions to cations in milliequivalents per litre (meq/l) and to identify mixing between different sources and changes in composition along flow paths. It is used to visualise the chemical composition of water from a particular aquifer or location. The ratio of cations and anions for groundwater samples from ECC and KP monitoring are plotted on a Piper diagram, as shown in Figure 6-5.

The following observations for the groundwater data were noted:

- Most water samples are dominated by carbonate (CO_3^-) and bicarbonate (HCO_3^-) anions except for EN-01 and OT-1. Samples from EN-01 have significant concentrations of chloride (Cl), showing anthropogenic impact. However, the samples show variable concentrations of alkalinity which may be due to seasonal trends.
- Samples from OT-1 have a trending increase in sulphates concentrations (SO_4^{2-}) and Cl, possibly due to anthropogenic activity.
- The water samples from borehole EN-01 have and increasing trend of calcium (Ca) cation concentrations than those from other boreholes.
- Most groundwater samples are plotted on the left quadrant of the Piper diagram in magnesium bicarbonate waters, typical of shallow groundwater with recent recharge.
- Samples taken from EN-01 and OT-1 exhibit a calcium chloride chemical signature. The samples are plotted on the upper quadrant of the Piper diagram and show elevated levels of salts, indicating anthropogenic activity. They could be attributed to farming in and around the area.

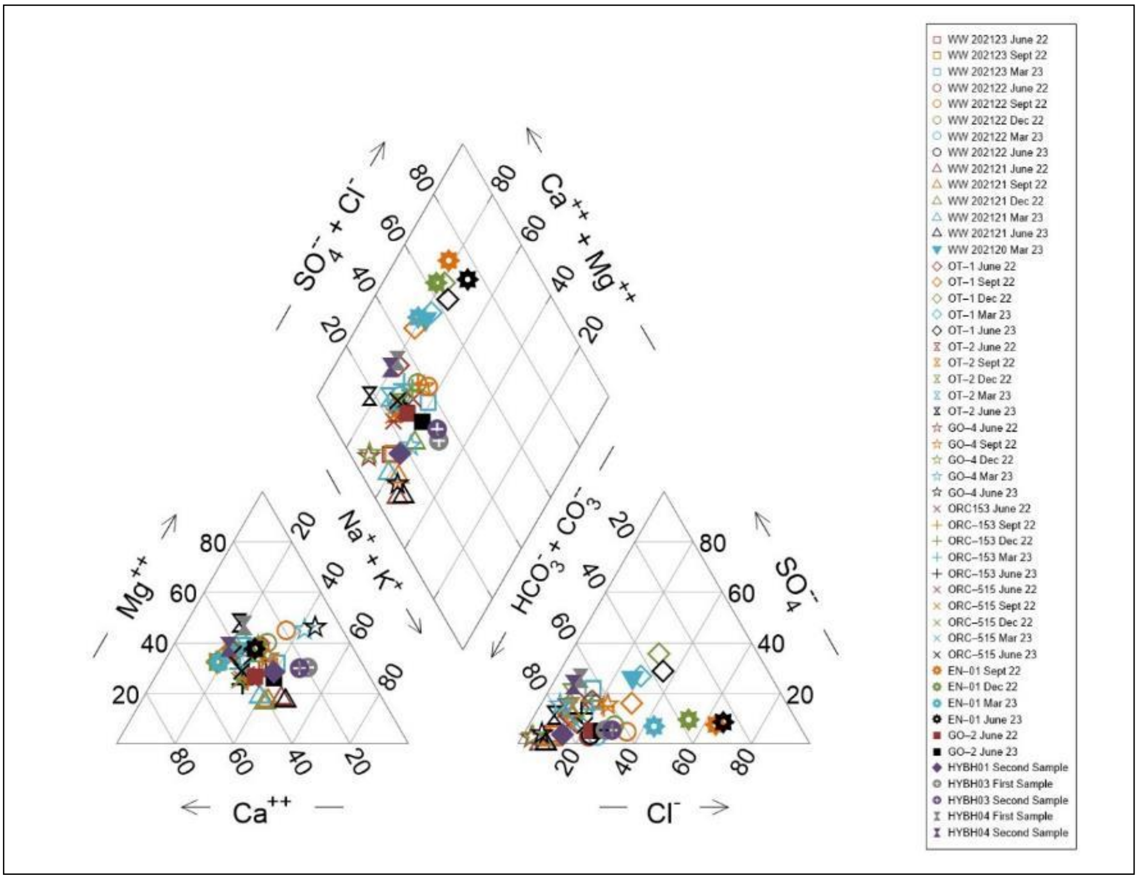


Figure 6-5 Piper Diagram of Samples

6.3.3 ISOTOPE ANALYSIS

Stable isotopes, specifically deuterium and oxygen ($\delta^{2}H$ and $\delta^{18}O$), in groundwater can be used to determine various aspects of hydrology and groundwater management. These isotopes can help in tracing the movement of water and identifying sources of groundwater recharge. They can also be used to understand the interaction between surface water and groundwater, as well as the interconnections between different aquifers. Additionally, stable isotopes can provide insights into the age of groundwater, the mechanisms and sources of groundwater pollution, and the effects of evaporation on groundwater systems, which is useful for groundwater management and understanding the contributions of different sources to groundwater recharge.

The meteoric water line (MWL) is a slope that shows the isotopic composition of hydrogen and oxygen isotope ratios in local precipitation. Any deviation from the line indicates mixing or isotopic exchange with other sources (Castañeda, Sucgang, Almoneda, Mendoza, & David, 2012).

Five groundwater samples were analysed for stable isotopes of deuterium (δ2H) and oxygen (δ18O) by iThemba Laboratory. The lab relabelled the samples as seen in Table 6-2 and are referenced as such in the laboratory certificate attached in Appendix 3.

The summary of the results of the stable isotope is shown below in Table 6-3; the $\delta^{18}O$ values range from -6.97 to -6.16 ‰, and the $\delta^{2}H$ values range from -49.44 to -41.82 ‰. The results of the stable isotopes are plotted on the $\delta^{2}H$ vs $\delta^{18}O$ graph along with the Global Meteoric Water Line (GMWL) and shown in Figure 6-6. The groundwater samples are plotted near the GMWL and exhibit slight deuterium enrichment which indicates that they have undergone evaporation prior to recharging the groundwater. HYBH03 is further from the river and could be subjected to slower time travel and evaporation through the low permeability vadose zone, before recharging the groundwater, compared to the losing Nossob River.

Table 6-2: Labelling of Samples Taken

Laboratory Number	Sample Identification
KP 139	HYBH01 end test pumping
KP 140	HYBH03 start test pumping
KP 141	HYBH03 end test pumping
KP 142	HYBH04 start test pumping
KP 143	HYBH04 end test pumping

Table 6-3 Stable Isotope Results for Omitiomire

Laboratory Number	$\delta^{2}H$	$\delta\ ^{8}O$
	(‰)	(‰)
HYBH01	-49,4	-7,0
HYBH03 First Sample	-42,2	-6,1
HYBH03 Second Sample	-41,8	-6,1
HYB04 First Sample	-45,8	-6,7
HYBH04 Second Sample	-46,5	-6,8

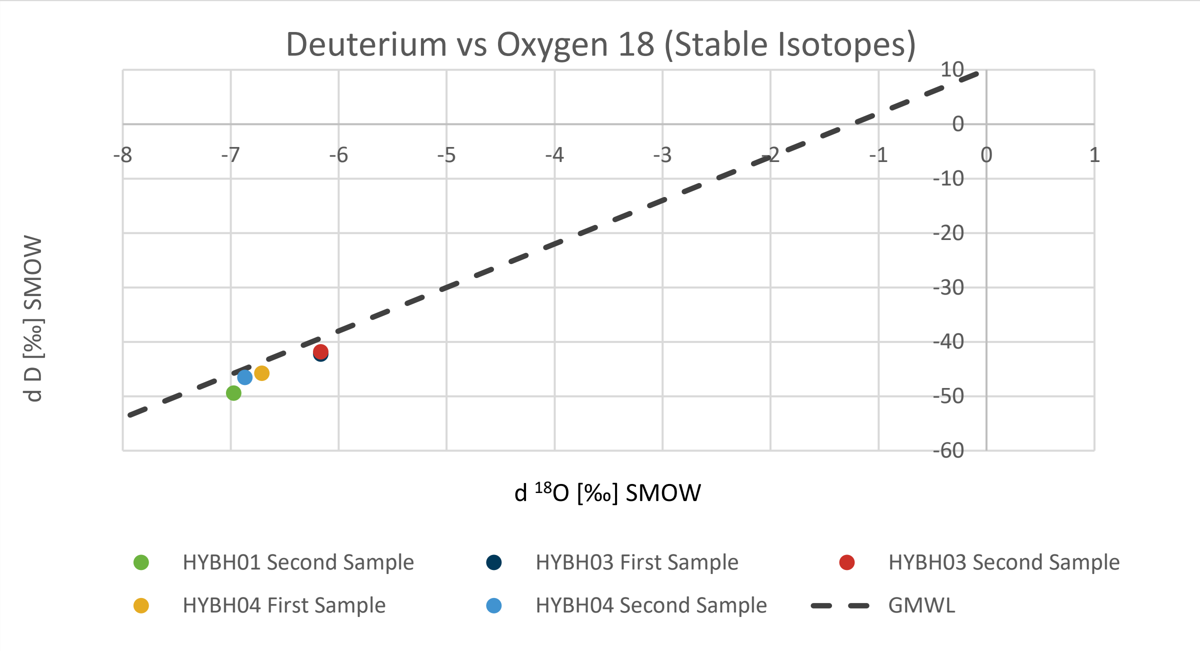


Figure 6-6: Deuterium vs Oxygen 18 Plot

6.3.4 RECHARGE

Recharge occurs between October and April, usually with an increase in January/ February, with May to September recharge is negligible (SLR Environmental Consulting, 2012).

There is limited local rainfall and isotopic data to calculate the recharge percentage (e.g. Chloride method). However, using the chloride method with regional rainfall data and local water chemistry data, recharge has been determined to be around 0.3% to almost 5% of MAP in some places.

6.3.5 LANGELIER SATURATION INDEX

The Langelier Saturation Index (LSI) measures the balance between water's calcium and alkalinity levels. It determines whether water is corrosive, balanced, or scale-forming. The LSI is an equilibrium model derived from the theoretical concept that indicates the degree of saturation of calcium carbonate in water. The index is not related directly to corrosion but to calcium carbonate film or scale deposition. When no protective scale is formed, the water is considered aggressive, and corrosion can occur, whereas an excess of scale can also damage water systems (Langelier, 1949).

The LSI value is calculated using a sample's pH, alkalinity, calcium concentration, total dissolved solids, and water temperature(Larson & Buswell, 1942). The indications for the LSI are based on the following values:

- **LSI<0**: Water is undersaturated with calcium carbonate. Undersaturated water tends to remove existing calcium carbonate protective coatings in pipelines and equipment.
- **LSI=0**: Water is considered to be neutral. Neither scale-forming nor scale-removing.
- **LSI>0**: Water is supersaturated with calcium carbonate ($CaCO_3$), and scale formation may occur.

The analysed samples show a variation in LSI indications. The following observations were noted:

- The samples show indications of -0.5 to 0 and 0 to 0.5, which depicts that the water is slightly corrosive, with some being non -scale forming and the rest scale forming.
- Few of the water samples show an LSI indication of - 2 to - 0.5 having serious corrosion, particularly ORC-513 and ORC-515, located along the Black Nossob River.
- WW202123 also has a corrosive indication. However, samples were not taken during all the sampling runs.
- LSI values of samples taken from the HYBH01, HYBH02, HYBH03 and HYBH04 are between 0.24 and 0.82, scale forming and slightly corrosive to non-corrosive in signature.

Table 6-4: LSI Indications

-2 to -0,5	-0,5 to 0	0	0 to 0,5	0,5 to 2
Serious corrosion	Slightly corrosion but non-scale forming	Balanced but pitting corrosion possible	Slightly scale forming and corrosive	Scale forming but non-corrosive

Table 6-5: LSI values of monitored boreholes.

	23-Jun-2022	15-Sep-2022	08-Dec-2022	08-Mar-2023	05-Jun-2023
ORC-153	-1,19	-1,19	-1,05	-0,82	-0,44
ORC-515	-0,62	-0,38	-0,53	-0,33	0,03
OT-1	0,51	0,26	-0,02	0,33	0,66
OT-2	-0,07	-0,21	-0,12	-0,1	0,38
WW 202121	-0,29	0,12	-0,25	0,01	0,15
WW 202122	0,25	0,35	-0,13	0,52	0,27
WW 202123	-0,33	-0,1		-3,25	
GO-4	-0,14	-0,17	0,07	0,95	0,79
EN-01		0,07	0,16	0,41	0,64
WW202120				0,37	
GO-2	-0,1				0,44
Contractors Borehole			0,13		
Okamapu BH1					0,17

Table 6-6: LSI values of pump-tested boreholes.

HYBH01 2nd Sample	HYBH03 1st Sample	HYBH03 2nd Sample	HYBH04 1st Sample	HYBH04 2nd Sample
0,24	0,51	0,82	0,79	0,41

6.4 GEOCHEMISTRY

6.4.1 HEAP LEACH RESIDUE

Craton requested that KP conduct a geochemical assessment of the leached residue material. To characterise the leached material, a 10-kilogram (kg) sample of leached residue from the ore was collected by Craton and submitted for static and kinetic geochemical testing at Waterlab (Pty) Ltd. laboratory in South Africa. The analyses included a duplicate of the same sample for quality assurance purposes.

The samples were classified per the South African NEMWA – Norms and Standards as specified in the Government Notices R. 63, 635 and 636 (Government Gazette No. 36784, 23/08/2013) of the National Environmental Management: Waste Act (Act No. 59 of 2008) by the Department of Environmental Affairs.

The static test results were completed in April 2023 [KP, RI23-00143], and based on the geochemical static test report, kinetic testing was recommended. The kinetic testing was performed on the same heap-leached residue material sample and completed in September 2023. This geochemical characterisation is based on the static and kinetic test results/analysis.

6.4.1.1 STATIC TESTING

Static testing allows the samples to be classified as Potentially Acid Generating (PAG), Non-Potentially Acid Generating (Non-PAG), or Uncertain:

- Acid-Base Accounting (ABA)
- Net Acid Generation (NAG) pH
- Inductively Coupled Plasma (ICP) Total Metals Scan

The geochemical characterisation evaluation is divided into three categories:

- Acid-generating potential (AP)
- Neutralising potential (NP)
- Metal leaching potential (ML)

The following assumptions and criteria were used to classify the acid-generating potential of the tested samples.

Samples are assessed in the following order:

- **Criterion 1**: If the sulphide concentration is greater than 0.3% by weight, the suggested classification is PAG.
- **Criterion 2**: If the neutralising potential/acid potential (NP/AP) ratio is less than 1, the suggested classification is PAG. The NP and AP values are usually reported in kg CaCO3 equivalent/tonne units.
- **Criterion 3**: The classification is non-PAG if the NP/AP ratio exceeds 2. If the NP/AP ratio is between 1 and 2, the suggested classification is Uncertain.
- **Criterion 4**: The suggested classification is non-PAG if the sulphide concentration is less than 0.3% by weight. However, samples with a sulphide concentration between 0.01 and 0.3% by weight and an NP/AP ratio between 1 and 2 are Uncertain (due to the material being primarily composed of minerals with poor NP values; Price, 2009).
- **Criterion 5**: If the NP/AP ratio is less than 1 and the NAG pH is less than 4.5, the suggested classification is PAG. If the NP/AP ratio is less than 1, but the NAG pH is greater than 4.5, the

suggested classification is Uncertain. The same applies if the NAG pH is less than 4.5 but the NP/AP ratio is greater than 1 (GARD Guide, 2009).

Neutralising potential is assessed by the Net Neutralizing Potential (NNP) values. A sample with an NNP of less than 20 kg $CaCO_3$ equivalent/tonne has little to no buffering (neutralising) capacity.

These criteria are typically used as guidelines when assessing the geochemical characterisation of samples and may not replicate during site conditions. The static testing results, as summarised in the Static Testing Memo (RI23-00143, Project RI301-00478) for the bulk sample of leached residue material and the duplicate sample, are briefly summarised below.

6.4.1.2 ACID GENERATING POTENTIAL

The acid-generating potential is assessed using two testing methods: modified ABA testing and NAG pH testing.

ABA Results.

Modified ABA test results are presented in the Static Test Memo together with the raw laboratory results which are presented.

- The total sulphur content of the samples ranges from 2.88% to 2.93%. All samples plot below the regression line which indicates that the sulphur is present mostly as sulphate which corresponds with the >7% jarosite in the XRD and not sulphide.
    - However, the sulphur-sulphide content for the samples is above >0.3% which classifies it as is potentially acid-generating (Criterion 1).
- The samples have an NPR of less than 1 and are therefore considered PAG (Criterion 2).

Based on the sulphur-sulphide content (Criterion 1), and the NP/AP ratio (Criterion 2), the tested samples would be classified as PAG.

NAG pH Results.

The Static Test Memo (KP, ref RI23-00143) presents NAG pH test results for the leached ore material.

To improve the prediction confidence, a comparison was made between the modified ABA and NAG pH results (GARD Guide, 2009). Samples with a NAG pH of less than 4.5 and an NP/AP ratio of less than 1.0 are considered PAG (Criterion 4). The acid-generating potential of a sample with an NP/AP ratio of less than 1.0 and a NAG pH greater than 4.5 is Uncertain (Criterion 5).

All samples had a pH greater than 4.5 and an NP/AP of less than 1, which indicates that the samples are uncertain (Criterion 5).

6.4.1.3 NEUTRALISING POTENTIAL

Carbonate is the most effective acid-neutralising mineral. The spent HLP material does not contain carbonate minerals, but silicate minerals (biotite) provide some buffering capacity. Samples recorded an NNP of -84 and -85, respectively, meaning there is little to no buffering capacity (Usher et al., 2003).

6.4.1.4 WASTE CLASSIFICATION

The following exceedances are noted for the TC (Aqua Regia digestion) (Table 6-7):

- TC of barium, copper, nickel and zinc exceed the TCT0 thresholds.

The following exceedances are noted for the LC (based on distilled water) (Table 6-8):

- The leachable selenium concentration is equivalent to the LCT0 threshold of 0.010 mg/l.

The general exceedance of the total concentration thresholds TCT0 for barium, copper, nickel and zinc and with leachable concentration (LC) of selenium equivalent to the LCT0 threshold but not exceeding the LCT1 threshold, classifies the leached ore as Type 3 waste, requiring a liner.

Table 6-7: Total Concentrations (Aqua Regia Digestion)

Sample ID	Craton Omitiomire residue Solid		Threshold	
Lab ID	**186098**	**TCT0**	**TCT1**	**TCT2**
Units	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
As, Arsenic	1.60	5.80	500	2.000
B, Boron	<10	150	15.000	60.000
Ba, Barium	376	62.50	6.250	25.000
Cd, Cadmium	<0.400	7.50	260	1.040
Co, Cobalt	28	50	5.000	20.000
Cr_{Total}, Chromium Total	572	46.000	800.000	N/A
Cu, Copper	921	16	19.500	78.000
Hg, Mercury	<0.400	0.93	160	640
Mn, Manganese	453	1.000	25.000	100.000
Mo, Molybdenum	8	40	1.000	4.000
Ni, Nickel	200	91	10.600	42.400
Pb, Lead	<0.400	20	1.900	7.600
Sb, Antimony	<0.400	10	75	300
Se, Selenium	<0.400	10	50	200
V, Vanadium	148	150	2.680	10.720
Zn, Zinc	752	240	160.000	640.000
Inorganic Anions				
Cr(VI), Chromium (VI) Total [s]	<0.200	6.50	500	2.000
Total Fluoride [s] mg/kg	10	100	10.000	40.000

Table 6-8: Leachate Concentrations (Distilled Water 1:20 Ratio)

Leachable 1:20	Craton Omitiomire residue Solid	Threshold			
Sample Number	**1**	**LCT0**	**LCT1**	**LCT2**	**LCT3**
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**
As, Arsenic	0.001	0.01	0.5	1	4
B, Boron	<0.025	0.5	25	50	200

Leachable 1:20	Craton Omitiomire residue Solid	Threshold			
Sample Number	**1**	**LCT0**	**LCT1**	**LCT2**	**LCT3**
Units	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**
Ba, Barium	0.006	0.7	35	70	280
Cd, Cadmium	<0.001	0.003	0.15	0.3	1.2
Co, Cobalt	<0.001	0.5	25	50	200
Cr_{Total}, Chromium Total	<0.001	0.1	5	10	40
Cr(VI), Chromium (VI)	<0.010	0.05	2.5	5	20
Cu, Copper	0.001	2.0	100	200	800
Hg, Mercury	0.002	0.006	0.3	0.6	2.4
Mn, Manganese	<0.001	0.5	25	50	200
Mo, Molybdenum	0.001	0.07	3.5	7	28
Ni, Nickel	<0.001	0.07	3.5	7	28
Pb, Lead	0.001	0.01	0.5	1	4
Sb, Antimony	<0.001	0.02	1.0	2	8
Se, Selenium	0.010	0.01	0.5	1	4
V, Vanadium	0.001	0.2	10	20	80
Zn, Zinc	<0.001	5.0	250	500	2000
Inorganic Anions					
Total Dissolved Solids	86	1.000	12.500	25.000	100.000
Chloride as Cl	3	300	15.000	30.000	120.000
Sulphate as SO_4	45	250	12.500	25.000	100.000
Nitrate as N	<0.05	11	550	1100	4400
Fluoride as F	0.5	1.5	75	150	600

6.4.1.5 KINETIC TESTING

Kinetic tests are usually conducted in columns to simulate the weathering of the materials in wet and dry cycles. The test aims to determine the rate of acid generation and variation over time in leachate water quality. The leachate from the columns is analysed weekly over 20 weeks for pH, EC, Sulphate, Alkalinity, and metal content. Results are presented in the Kinetic Test Memo (KP, Ref RI23-00439).

Heap Leach Residue Material Sample

The leachate has an acidic pH value ranging from 3.99 to 5.90. The sample had an average pH of 5.4. Initially, the pH was very low at week 1 with a pH value of 3.99, but there was a gradual increase by the end of week 20 with a pH value of 5.73, and the highest pH was observed in week 18 with a value of 5.90.

- Alkalinity loading values were below the detection limit for the entire duration of the test program.

- Sulphate loading values were elevated in week 1, with a concentration of 2347 milligrams per litre (mg/l). The sample was made up of 7.94 percent (%) Jarosite, which is a sulphate-bearing mineral. The sulphate loadings decrease through week 20. The elevated concentration is associated with the flushing of readily soluble constituents in the early stages of the test (initial flush). After the final week of testing, the sulphate concentration had decreased to 33 mg/l.

The results have been compared to the International Finance Corporation (IFC) mining effluent standards.

- The heap leached residue material sample exceeds the IFC limits Guidelines for copper (Cu) during weeks 1, 3,4 and 11.
- The IFC limits are exceeded for Iron (Fe) during week 11, nickel (Ni) and zinc (Zn) during week 1.
- After 20 weeks of testing, the heavy metals concentrations are below the IFC limits.
- The pH exceeds the IFC limits for the entire testing program. The acidic pH is likely due to the processing of heap leaching the material, which uses sulphuric acid and not only due to the oxidation of sulphides.
- The kinetic test results confirm the static SPLP results, which showed that most heavy metal concentrations are low and well within the LC limits after twelve weeks of the humidity cell test.

The HLP will be lined with clay and HDPE, with leak detection with underdrainage, therefore, minimising the risks to groundwater. This summary is based on results from testing completed in 2023. Any changes after 2023 to the processing and/or heap leach pad development may impact the chemical makeup of the resulting heap leach pad. As such, it is recommended that additional static testing (3 to 5 samples) and kinetic testing (1 humidity cell) programs be completed from materials available from any future pilot plants, if applicable.

6.4.2 WASTE ROCK MATERIALS

ECC and RGS has completed a static geochemical assessment program of representative samples of mine materials from the Project including waste rock and ore materials (ECC-134-439-REP-01-A, May 2023). A total of 96 drill samples representing waste rock and ore materials associated with Project was geochemically characterised using static test methods.

The geochemical assessment found that:

- The overwhelming majority of the mine materials have low sulphur content, excess NP and are classified as NAG (Barren). Some of the high-grade ore samples have elevated sulphur content and limited NP and are classified as Uncertain.
- The mine materials typically have low total metal and metalloid concentrations in waste rock compared to global median crustal abundance in unmineralised soils. The main exceptions are slight enrichments with Ca, Cu and Mo.
- Surface runoff and seepage from mine materials is expected to be slightly alkaline, have low salinity and generate low concentrations of dissolved solids. Soluble major ion concentrations are expected to be relatively low in initial contact water with waste rock.
- The concentration of trace metals/metalloids in surface runoff and seepage from mine materials is expected to be low and the risk of potential impact on the quality of surface and groundwater resources from initial contact with mine materials at the Project is also expected to be low.

6.5 GROUNDWATER RECEPTORS

Adjacent farmers are concerned about the impact of the project on their water supply, as they abstract groundwater from boreholes near the proposed mine boundary, mainly from the weathered aquifer associated with the Nossob alluvial deposits and other deeper boreholes in the fractured rock aquifer.

There are potential sources of groundwater contamination from the Waste Rock Dump (WRD) and Heap Leach Pad (HLP). While the design of the HLP will be lined to limit seepage and consequent contamination, the WRD will not be lined and may become the primary source of contamination.

The following have been identified as potential receptors:

- The Black Nossob River that runs through the proposed mine boundary is ephemeral, with rainfall events and occasional river flows recharging the groundwater levels up to surface level.
- The surrounding farms are owned by private individuals, and some boreholes are being used for water supply.

7.0 HYDROGEOLOGICAL CONCEPTUAL MODEL

The Conceptual Hydrogeological Model (CHM) has been developed to highlight the critical hydrogeological aspects impacting groundwater flows during and after mining.

Rainfall in the area is spatially variable and occurs as high rainfall events. The recharge to groundwater is expected to be low over much of the region, with slightly enhanced recharge from the alluvials and deeper weathered fault profiles.

The site is at the top of the Black Nossob catchment area, which eventually flows into the White Nossob River. The Black Nossob is an ephemeral river, with the subsurface flow in the alluvials resulting from direct recharge and not baseflow from the regional groundwater table. The alluvials comprise sandy clays and could have clay lenses where there is an increased storage capacity of groundwater.

Recharge in the area is relatively low, with much of the surface flow evaporating before infiltration. The overburden cover is relatively thin, and the fractured rock is intercepted at a shallow depth. The topography across the site is very flat, with multiple depressions where calcareous deposits have formed and where overland flow accumulates and is subjected to evaporation.

Regional groundwater ranges from 15mbs to more than 30mbs in areas. The primary aquifer is a fractured aquifer within the metamorphosed gneiss and amphibolites. The primary porosity in this aquifer is very low, and the fracture networks govern groundwater flow.

The regional groundwater flow is predominantly from the northwestern region and flows to the south toward the Nossob River. During the rainy season, the river will likely be a losing connected river, where water infiltrating from the river base is connected to the regional groundwater table (Figure 7-1). However, in the dry season, the river possibly becomes disconnected from the regional groundwater table.

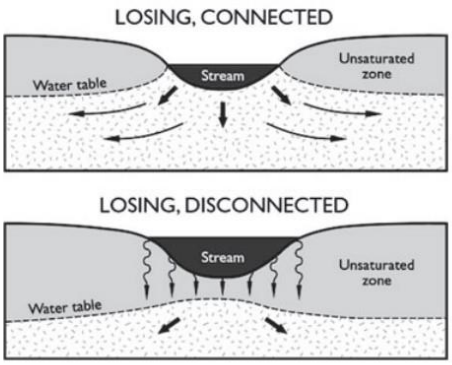


Figure 7-1: Suggested Different flow regimes for the Black Nossob River between surface water and groundwater (figure based on Winter et al. 1998; Brunner et al. 2009a)

The weathered to fresh rock transition zone has variable depth, where it extends deeper where there are faults. Figure 7-2 illustrates the main groundwater features and how the proposed mining infrastructure and excavations could impact them.

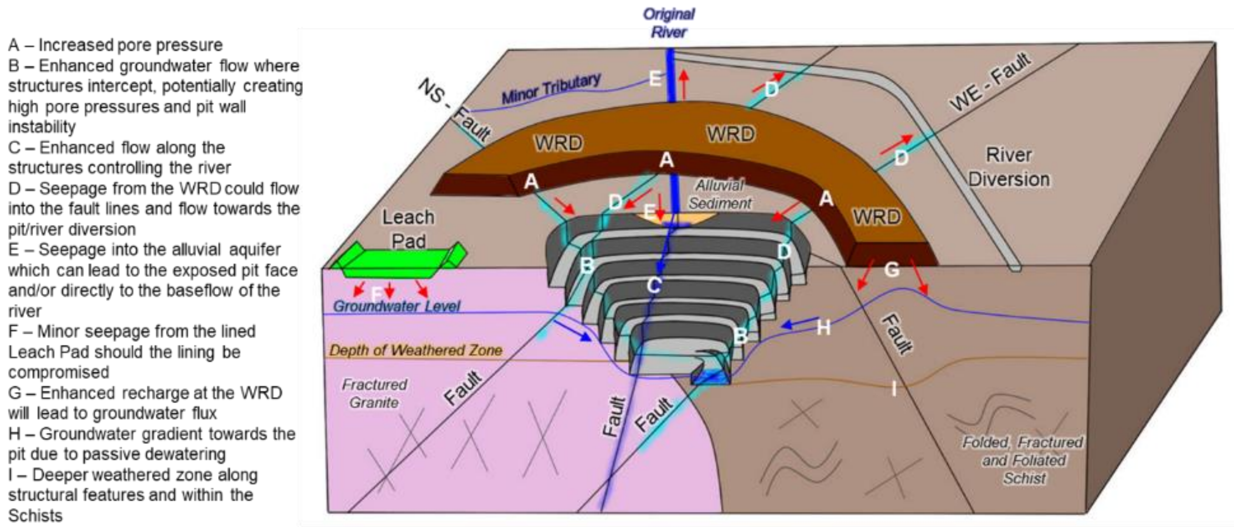


Figure 7-2: Conceptual Hydrogeological Model and Key aspects to be investigated.

The proposed river diversion will direct surface flow around the pit and result in the river being disconnected from the groundwater flowing within the structures. The river section impacted by the river diversion will become directly affected by mining activities, which could impact the groundwater recharge in the mine area. The enhanced recharge at the WRD site will off-set any impact the river diversion will have on the groundwater recharge along the river. In addition, the pit will become an evaporation sump, resulting in a drawdown cone extending further than the river diversion's full extent, so seepage from the unlined channel will be captured.

Potential sources of contamination from the proposed mine will primarily occur from:

- The unlined WRDs. Seepage, quickflow, and surface runoff from the WRDs will flow towards the Black Nossob and into the alluvial deposits. However, the flow will inevitably be captured by the cone of drawdown created by the pit excavation before migrating downstream.
- The Heap Leach Pads which will be lined.
- The open pit, use of explosives can result in nitrate contamination.
- Heavy machinery, fuel and diesel spills.

8.0 3D HYDROSTRATIGRAPHIC MODEL

Leapfrog Works® is a 3D geological modelling software developed by Seequent. The Leapfrog software uses implicit modelling to create models by defining geological domains and assigning their properties instead of relying on traditional grid-based methods. This approach allows for more flexible and intuitive modelling considering geological interpretations and observations. Leapfrog provides for data integration, 3D visualisation, interpolation and gridding, and uncertainty analysis.

8.1 AVAILABLE DATA

Data collected during this study was brought into the Leapfrog model to generate a 3D representation of the hydrostratigraphy in the Omitiomire area (Figure 8-2).

8.1.1 DATA LIMITATIONS

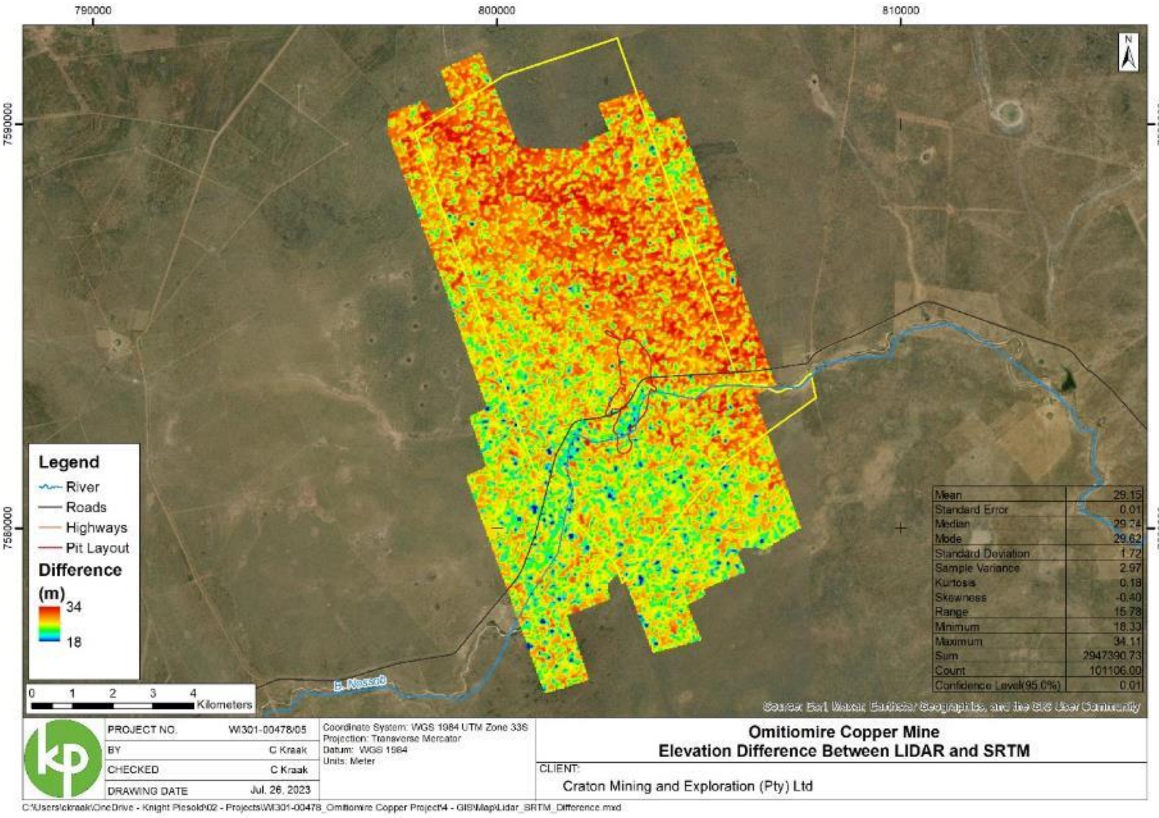


Figure 8-1: Elevation difference between LIDAR and SRTM Data

8.1.2 DATA UTILISED

The following data and interpolations were incorporated in generating the 3D Hydrostratigraphic Model.

Table 8-1: Input data for the 3D Omitiomire Hydrostratigraphic Model

Item	Data
Topography	Satellite Radar Topography Mission (SRTM) raised 30m to fall in line with the LIDAR data.
	LIDAR data
Geology	Geological map of Namibia
	Regional Geophysics (FinalInterpMap_GeoTIF, Remote Exploration Services (Pty) Ltd. 2008)
	Regional Gravity
	Geological Logs (Omitiomire Assay_Geol150121, Omitiomire Collar150225, Omitiomire Survey150225)
	Geotechnical Logs, (KP, 2023)
	Hydrogeological drilling logs (KP, 2023)
Structures	"Interp all _layers 7Sep09" TIF file was used to delineate regional structures. Ground Mag 2009
	ERT Geophysics results
	Geological Logs (Omitiomire Assay_Geol150121, Omitiomire Collar150225, Omitiomire Survey150225)
Model Boundary	Boundary derived for the numerical model, KP 2023

8.2 MODEL GENERATION

The following tasks were undertaken to generate the 3D model:

- The adjusted SRTM and LIDAR data were used to create the wireframe for the topography and the upper boundary of the model.
- The drillhole data provided by the client was analysed and grouped into hydrostratigraphic units.
- The geology shapes derived from the Namibian Geology Maps generated the required geological units.
    - These units were refined using the drillhole data.
- Structures were delineated from the regional structural interpretation done by (Ground Magnetics for Omitiomire, 2009). These were brought into the model to trace chosen faults.
- The ERT cross-sections generated from the geophysical survey for this project were used in conjunction with the delineated structures to interpolate these features in 3D.

8.3 LIMITATIONS AND ASSUMPTIONS

The data provided and sourced had several limitations that lowered the confidence level of the Leapfrog model. The following limitations and assumptions are noted:

- The surface geological information is taken from 1:25 000m and 1:100 000m geological maps.
- The SRTM data used to generate the regional topography and to supplement gaps in the local topography data provided is of low resolution (30m) and is not 100% accurate.

- The LIDAR data provided by the client is 27 to 34 meters above the Shuttle Radar Topography Mission (SRTM) data (Figure 8-1).
    - The difference is more in the north and lessens towards the south of the project area.
    - The client is aware of this discrepancy and has indicated that the resource models, the mine design, and other mine infrastructure are being designed using the LIDAR data.
    - Therefore, a decision was made to move the SRTM data up by 30 m to correspond with the LIDAR data. The adjustment is a temporary fix, as the differences between the two datasets are variable. It is recommended that the LIDAR data be re-evaluated in a global ellipsoid and the required updates be made.
- The resolution of the wireframes generated in Leapfrog varies from 500 m to 50m.
- The previous hydrogeological work undertaken for Omitiomire Copper Mine was several years ago, and the raw data has since been lost. The remaining information is directly from the reports.
- Due to the change in topography elevation, the geophysical surveys provided by Greg Symons Geophysics were adjusted to meet the model topography.

Figure 8-2 is an oblique view of the 3D hydrostratigraphic model developed in Leapfrog Works®, which was used to construct the FEFLOW numerical model.

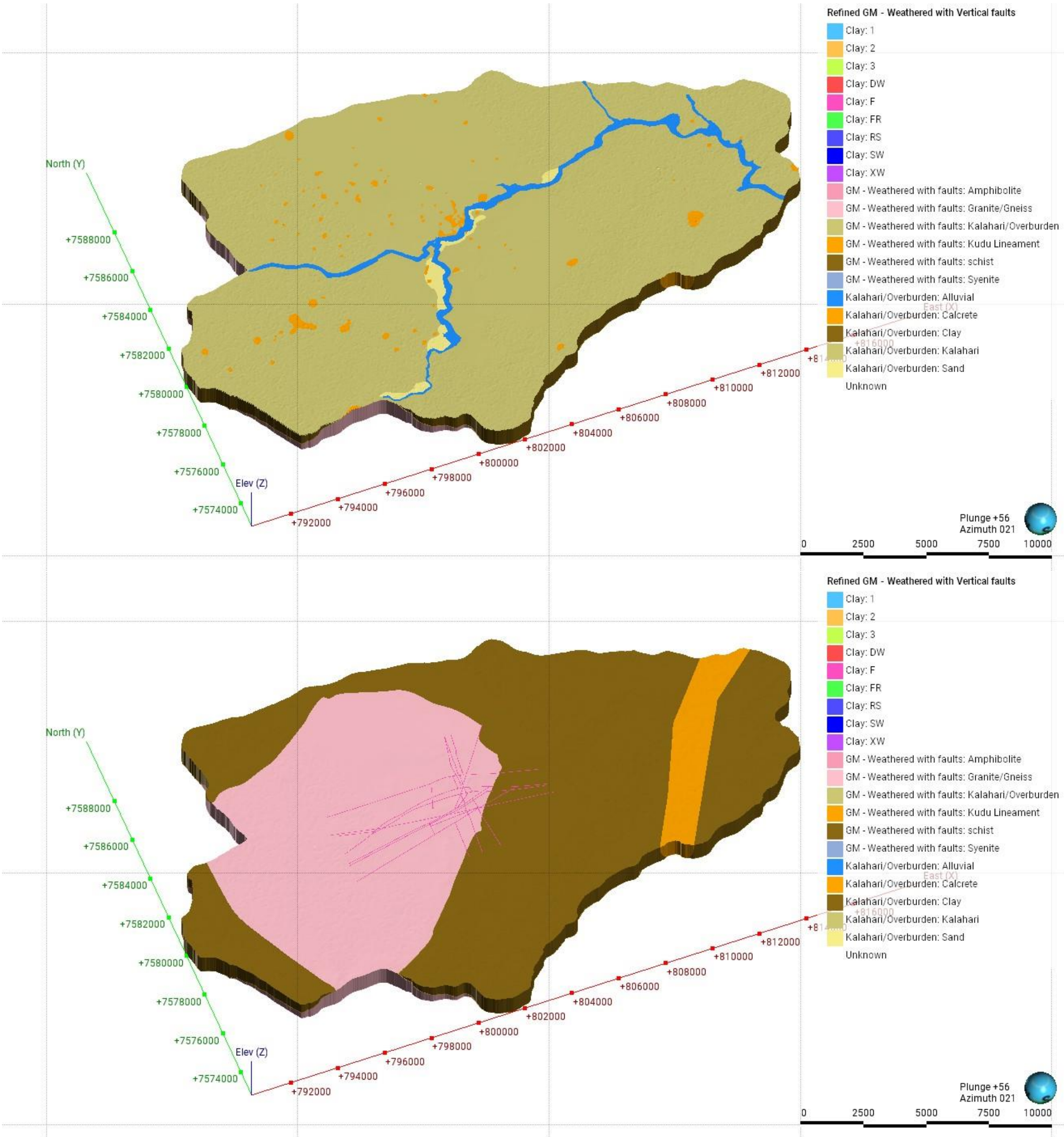


Figure 8-2: 3D hydrostratigraphic model

9.0 NUMERICAL MODEL

The hydrogeological conceptual model generated in Leapfrog Works® was used to create a 3D hydrogeological numerical model in DHI's FEFLOW 8 software and constructed using available data and information regarding geology and groundwater parameters.

The main objective of the numerical groundwater flow model is to develop a representation of the actual groundwater regime and flow conditions in the project area. This model was then utilised to:

- Simulate future stresses on the groundwater due to the river diversion and mining activities.
- To determine inflow rates into the open pit development during the life of the Mine (LOM) and post-mining.
- To simulate possible plume migration from future waste facilities.
- To simulate the cone of drawdown and impact on receptors.

9.1 MODELLING FRAMEWORK

There are two significant aquifers: the shallow aquifer, an unconfined aquifer in the alluvium, and the deep aquifer, the confined fractured aquifer in the hard rock. The unconfined aquifer was simulated by using the free surface option in the problem class, and this allows a more accurate simulation of the phreatic surface, flow and solute transport in the partially saturated zone.

The deepest mine final plan is 1400 mamsl, meaning the mine will be about 290 m deep at the end of LOM. The top boundary of the model is based on the surface elevation, and its bottom is at 700 mamsl, which is 600 meters below the mine's final plan. Therefore, the model bottom boundary is not affected by mining activity and will allow for deeper mine plan updates in future if required.

The model's boundary has been delineated at a distance sufficiently far from the boundary of the pit. The closest boundary distance from the mine is almost 5 km, 14 times the mine depth, meaning the boundary will likely not be impacted by the cone of depression. The Black Nossob River tributaries and sub-watersheds were considered in delineating the numerical boundary.

The layers are refined in the unsaturated area to avoid numerical instability, where the distance between the first three top layers is 3 m. The distance between the lower layers is 15 m down to the bottom of the final pit; the rest are 35 to 50 m, excluding the bottom layer (from 770 to 700 m), which has 70 m thickness. The node density varies in the model domain and along the river and faults. The dominant distance between two nodes in the model domain, river and faults, is as follows: 270- 470 m, 130-190 m, and 10- 40 m, respectively. In the transient state, the meshing is refined for the pit, waste rock dumps (WRD) and river diversion areas to meet the solution standards. The total number of model layers before and after adding the WRD are 42 and 52.

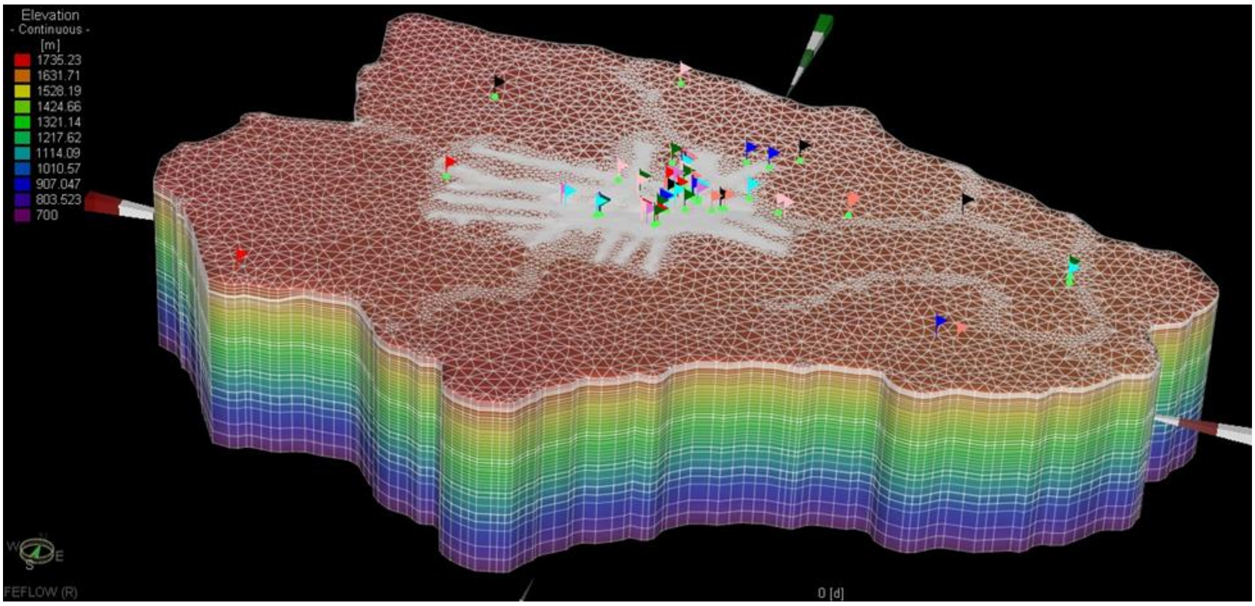


Figure 3D model showing the layers, meshing and observation wells (flags) under steady-state conditions.

9.2 MODEL BOUNDARY CONDITIONS

Three main boundary conditions are assigned to the model boundaries: no-flow, constant and fluid flux (general head). Geological information, water surface bodies, and hydrogeological conditions are the key factors to be considered when designing these conditions for the model boundaries. Although metamorphic rocks are the geological formations of hard rock, there is no known no-flow boundary in the project since the hard rock is fissured. There is not enough information on the amount of fluid flux (limited regional data on hydraulic conductivity) across the surrounding model boundary. Accordingly, Constant head boundary conditions with a specified head (Dirichlet boundary) are assigned to the surrounding numerical boundary.

The groundwater head of the delineated boundary was obtained; more than 7000 points from the Namibian Borehole Database were used to acquire a precise hydraulic head. It is assumed that these data are representative of the steady-state conditions. However, using the best representative data of the steady-state conditions in a time series is preferred.

Further, non-uniform areal recharge was defined as specified flux (Neumann boundary) over the model's top. Recharge at the river and pans was enhanced.

9.3 INPUT PARAMETERS

Hydraulic conductivity (K) and recharge rate are the two essential input parameters for the geological formations constructed in the Leapfrog model. K values were first assigned to the model considering Table 6-1. The recharge coefficients were selected as 0.01, 0.02, and 0.03 for the model domain, pans, and river. These values are refined during calibration to match the observed and computed hydraulic heads best.

9.4 LIMITATIONS AND ASSUMPTIONS

The following limitations and assumptions are noted:

- Since the groundwater measurements were in the open holes, the exact location of the layer that impacts the groundwater head is unknown.
- Limited aquifer data is available for the schist units.
- The reliability of the groundwater measurements from the regional observation wells is low. The discrepancies between the SRTM topography and the LIDAR topography are an issue; the merge of the two topographies was used for the model top layer, which has 4 m elevation differences in some areas.
- The faults are assumed to be vertical.
- There are no measurements for the effective porosity, longitudinal and transverse dispersivities, diffusion coefficient, recharge coefficient and fluid flux from the WRDs. Therefore, these parameter values were assumed to be within the range of the feasible hydrogeological sense of the area.
- The WRD material is modelled as homogenous and omits possible quickflow zones and direct run-off.
- The shallow weathered aquifer has been modelled as an unconfined aquifer, and the regional fractured aquifer has been modelled as confined.
- Due to the data limitations, a semi-saturated model could not be developed. Therefore, the Darcy Flow equation was used, which requires saturated conditions and limits the model's ability to accurately simulate flow in the transiently semi-saturated alluvials. This results in perched water tables not being accurately simulated.

9.5 STEADY-STATE CALIBRATION

The model was run without any mining facilities under steady-state conditions. The hydraulic conductivity and recharge were used to calibrate the model based on the groundwater measurements in the observation wells (OW). Based on the calibration graph with root mean square (RMS) of 6 (Figure 9-1), the holes near the river show a lower correlation between the computed and observed hydraulic heads, i.e., the difference between the two heads in WW202121 is 15 m due to the groundwater level oscillations near the river. BH05-SWD is the least calibrated OW with a measured hydraulic head of 1681 m, and the computed hydraulic head is 1666 m, which is very close to the other nearby OWs, including BH02-SWD and BH03-SWD.

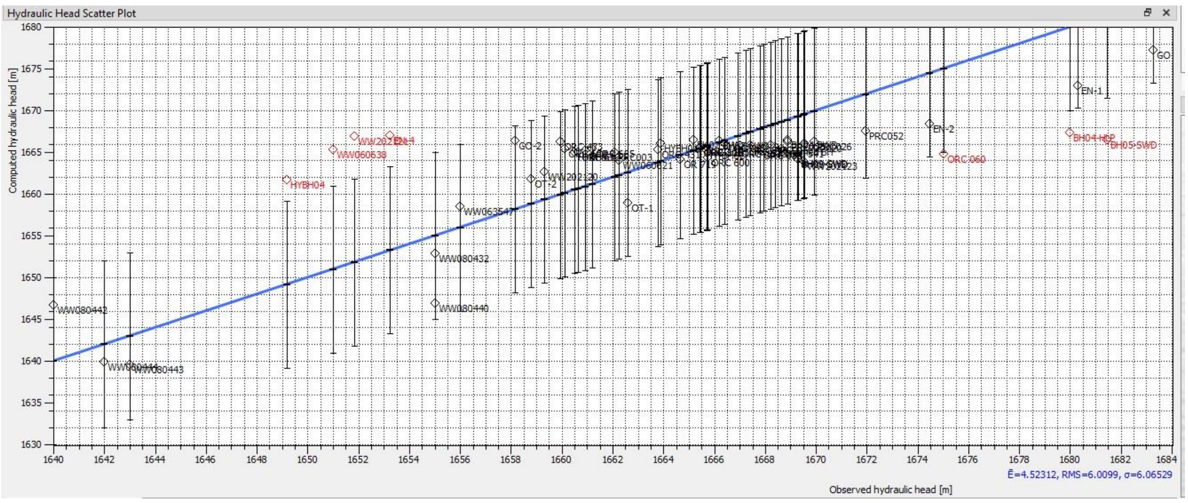


Figure 9-1: Calibration graph under the steady state condition.

The calibrated Ks, shown in Figure 9-2, range from 0.002 m/d to 0.15 m/d for Kx and Ky; Kz is 0.10 of Kx. The river deposits in the top shallow aquifer have the highest Ks, while the hard rock, which is the matrix, has the lowest Ks. The faults Ks decrease with depth from the top layers just below the alluvium to elevation 1545 m; they are assigned 0.10 m/d to lower layers below this depth at 0.06 m/d.

Figure 9-3 illustrates the calibrated recharge in the top layer, which ranges from 1.38 to 3.78 mm/y. The mean annual precipitation (MAP) on-site from 2008 to 2011 is 508 mm, but it is more likely that the MAP in the longer term is less and closer to the 400 to 450 mm catchment MAP. Using the latter MAP, the recharge coefficient varies from 0.003 to 0.01, which can increase to 0.028 (12.70 mm/a) in the rainy months.

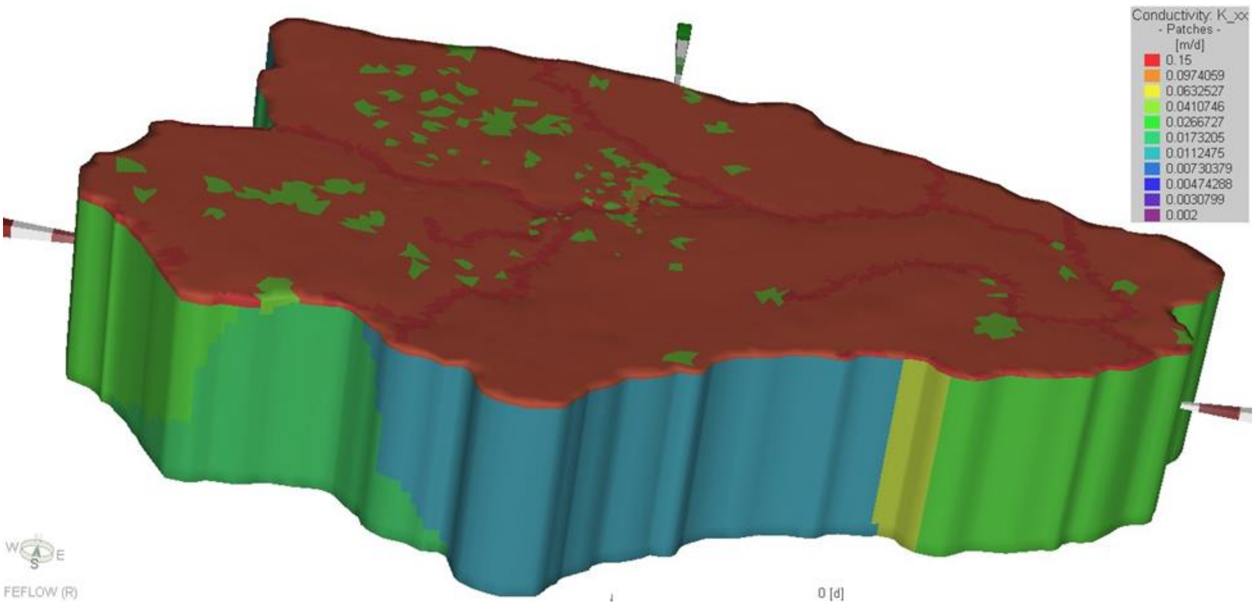


Figure 9-2: Calibrated hydraulic conductivities.

Figure 9-3: Calibrated recharge in the top layer.

9.6 TRANSIENT STATE SIMULATION

9.6.1 RIVER DIVERSION

The subsurface flow in the river is represented in the first four layers of the numerical model, with a thickness of 12 m. The groundwater level is 12 to 20 m below the ground surface. Therefore, the probability of baseflow into the river diversion channel is low, considering that the channel depth is 10m. The difference between the maximum and minimum measurements in the observation wells (OW) is more noticeable in those near the river. For example, WW202120 shows a 17 m fluctuation, the highest among all OWs.

Darcy flow in FEFLOW refers to water flow through a porous medium, calculated using the Darcy equation of fluid motion and the fluid mass conservation equation. The Darcy-flux vector field is calculated from the simulation run in FEFLOW and is a distributed value during the simulation.

The structure locations (faults), Hydraulic head (HH) isolines, and Darcy flux in the river diversion are illustrated in Figure 9-4. The Darcy flux values are similar in the first three layers of the groundwater numerical model, where the maximum is 0.267 metres per day (m/d) and occurs near the inlet of the river diversion. The maximum Darcy flux is much smaller in the fourth layer than that of the three first layers, which is 0.024 m/d (Figure 9-4).

After mining excavation passes 10 m depth, the flow direction will be towards the mine due to the cone of drawdown. Therefore, the impact of the river diversion on the groundwater is minor compared to the effect that the mine workings and pit excavation will have. This is further discussed in Section 9.6.2.

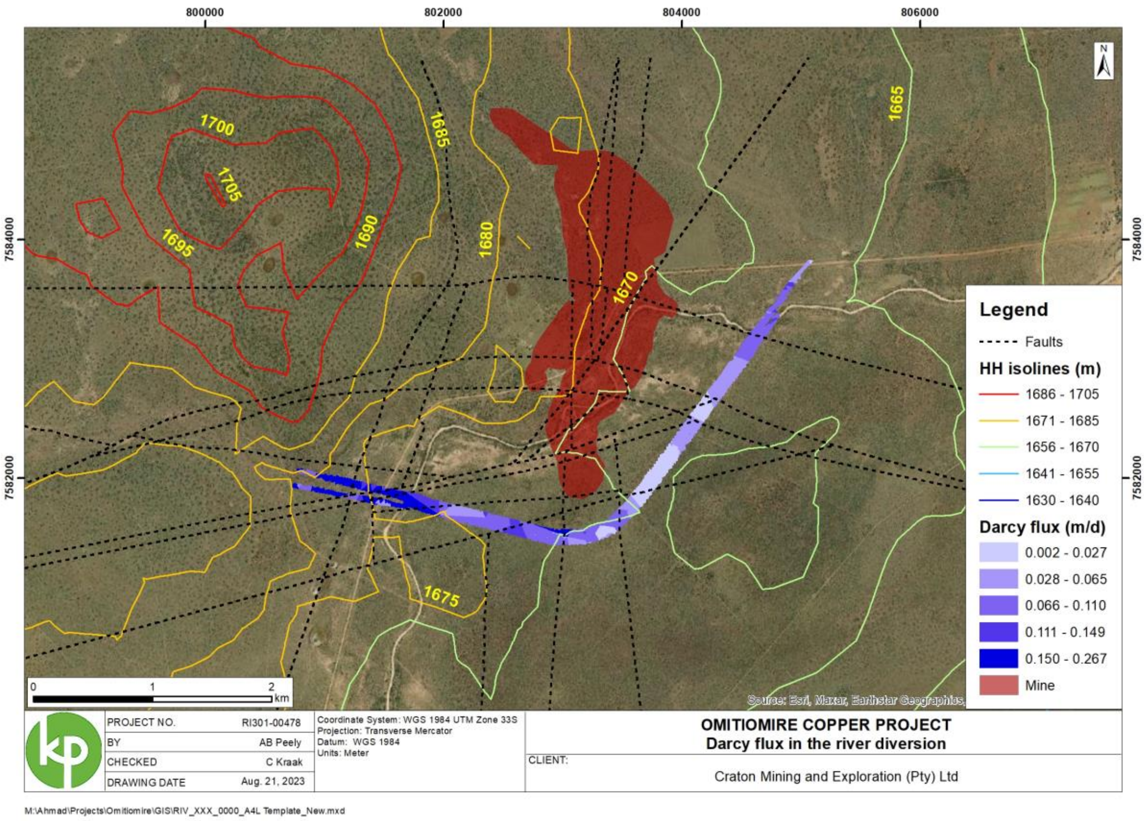


Figure 9-4: Darcy flux in the first layer in the river diversion.

9.6.2 MINE PLANS

The numerical model includes ten years of mine pit design (Yearly Surface.7z provided by Ed Baldrey on the 8th of October, 2023), WRD design and the HLP. The WRD plans are defined in the model so that each layer has a 5 m thickness. The elevation of the WRDs starts from 1680 to 1735 mamsl shown in Figure 9-5 with LOM. The highest elevation within the model boundary is 1735 mamsl in the northwestern corner, the same as the highest elevation plan of the WRDs.

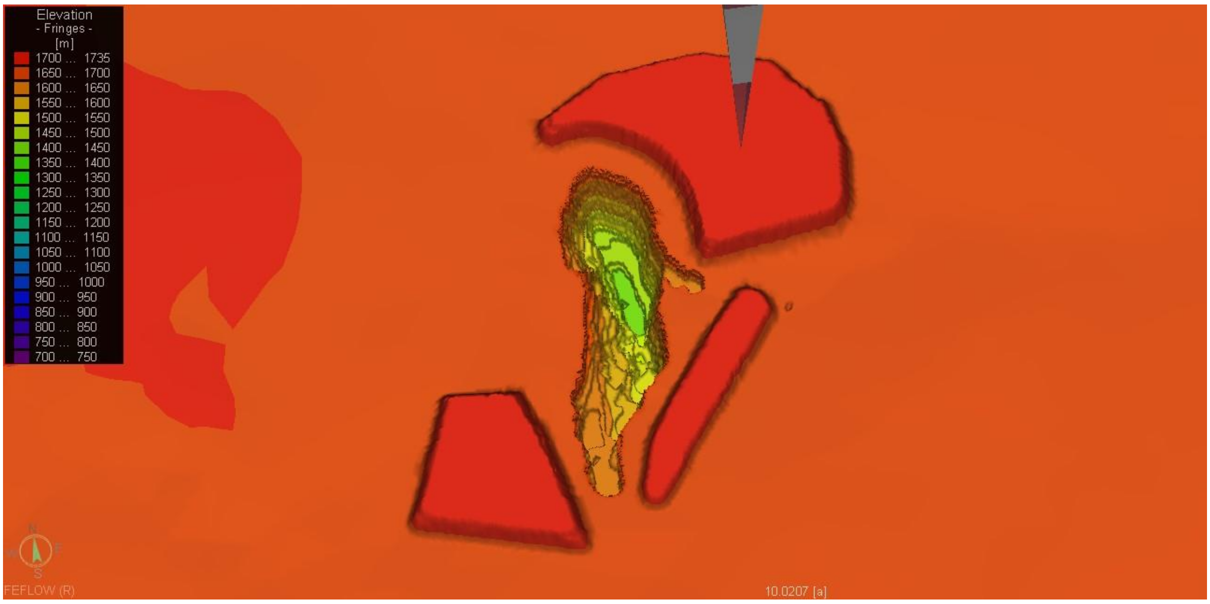


Figure 9-5: 3D illustration of the elevation of the top layer with the WRDs and LOM

9.6.3 NUMERICAL MODEL RESULTS

Figures 9-5 to 9-7 show the regional hydraulic head, pit hydraulic head, and pore pressure behind the pit benches in years 2, 5, 8 and 11. It has been observed that the cone of drawdown starts steep and close to the pit walls (the maximum drawdown is from 14 to 67 m from year 2 to year 11, respectively) and rapidly becomes shallower with a gentler slope with distance from the pit. Over time, from year 2 to year 11, the cone extends laterally with a distance from the pit from 1 to 3.5 km with a 5 m drawdown (Figure 9-9). The direction of the maximum expansion is along the structures. After closure, the pit will continue acting as a regional sink and draw groundwater and potential contaminants towards the pit. The COD, 50 years post-closure, extends to a maximum of 4.5 km from the pit centre and does not reach the Nossob River (Figure 9-10).

The hydraulic head distribution in the pit in the deeper layers (i.e. deep aquifer) is shown in Figure 9-7. The pore water pressure behind the pit walls is influenced by the hydraulic properties of the layers, enhanced recharge, lithostatic pressures from the WRDs and the pit shape.

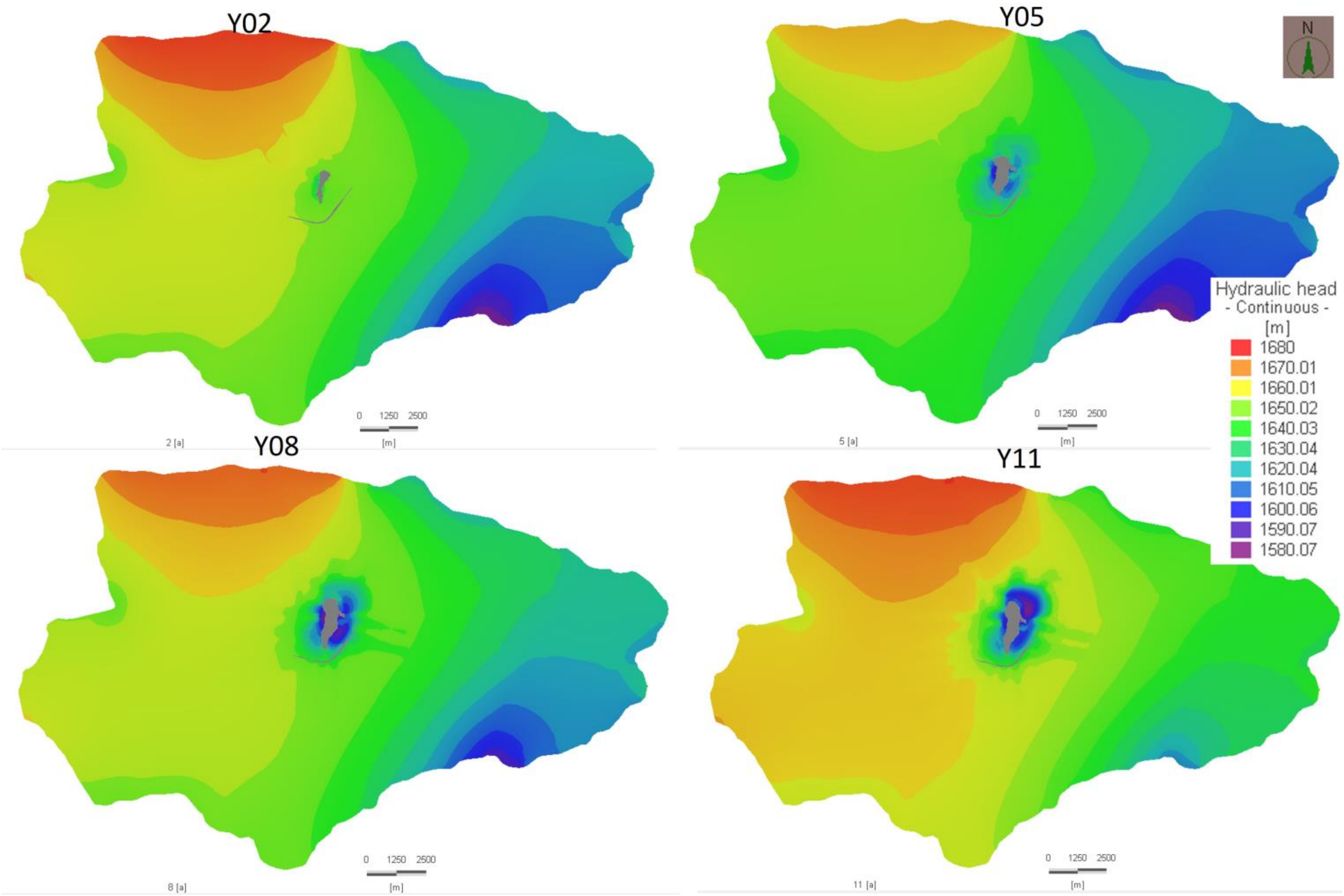


Figure 9-6: Hydraulic head in mamsl for years 2, 5, 8 and 11 in the model domain (shallow aquifer)

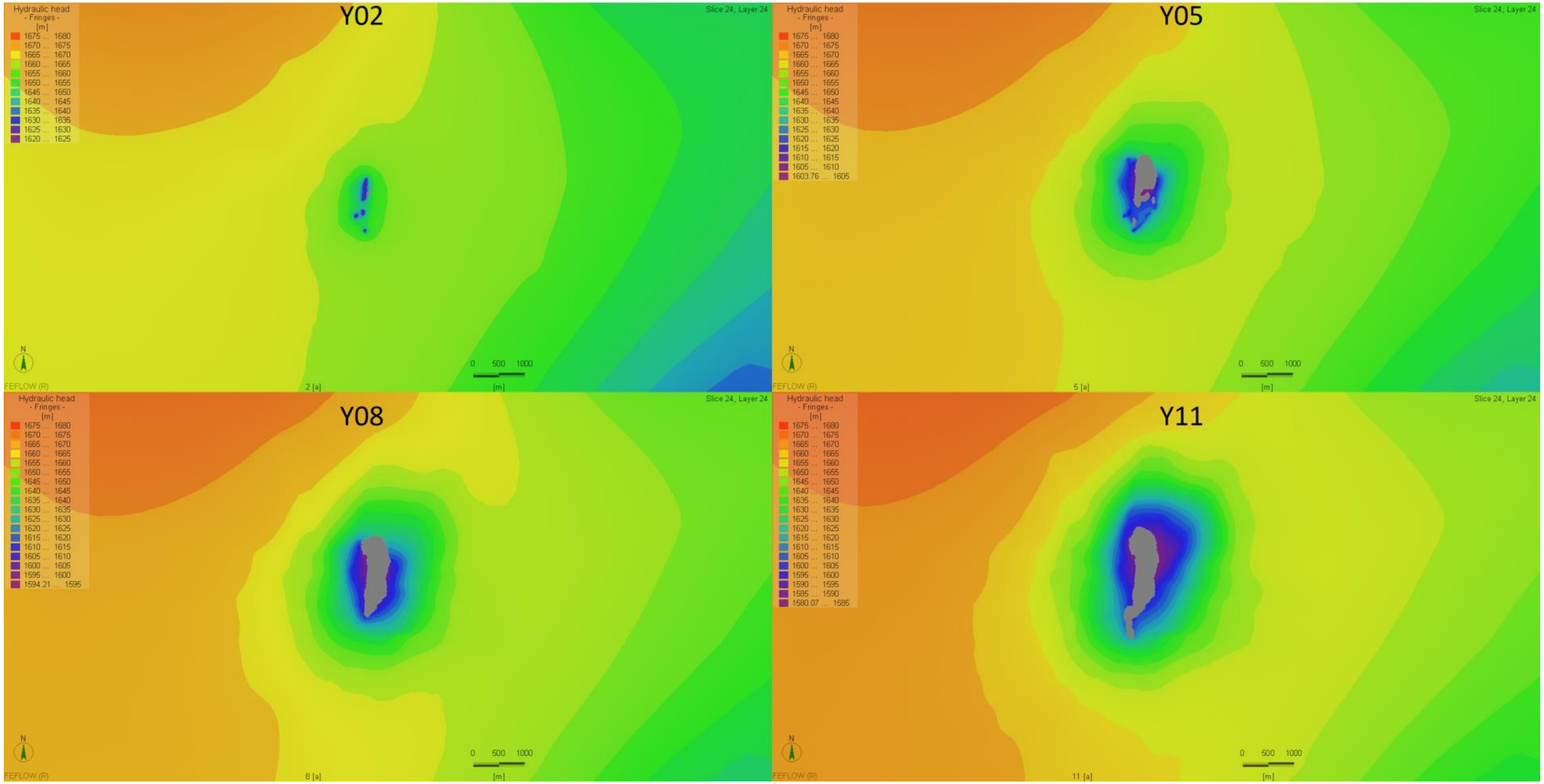


Figure 9-7: Hydraulic head in mamsl for years 2, 5, 8 and 11 in the pit (deep aquifer)

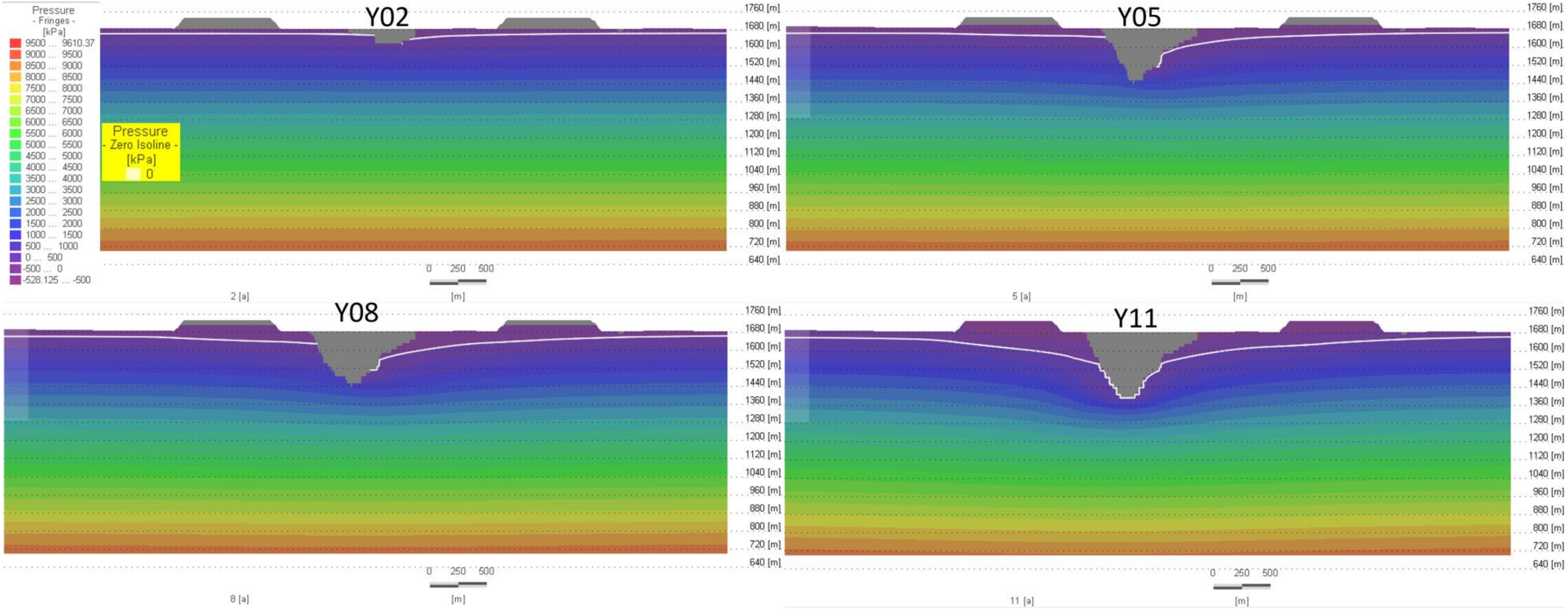


Figure 9-8: Pore pressure behind the mine benches in a cross-section (2x exaggeration) from north to south in years 2, 5, 7 and 10(2x exaggeration)

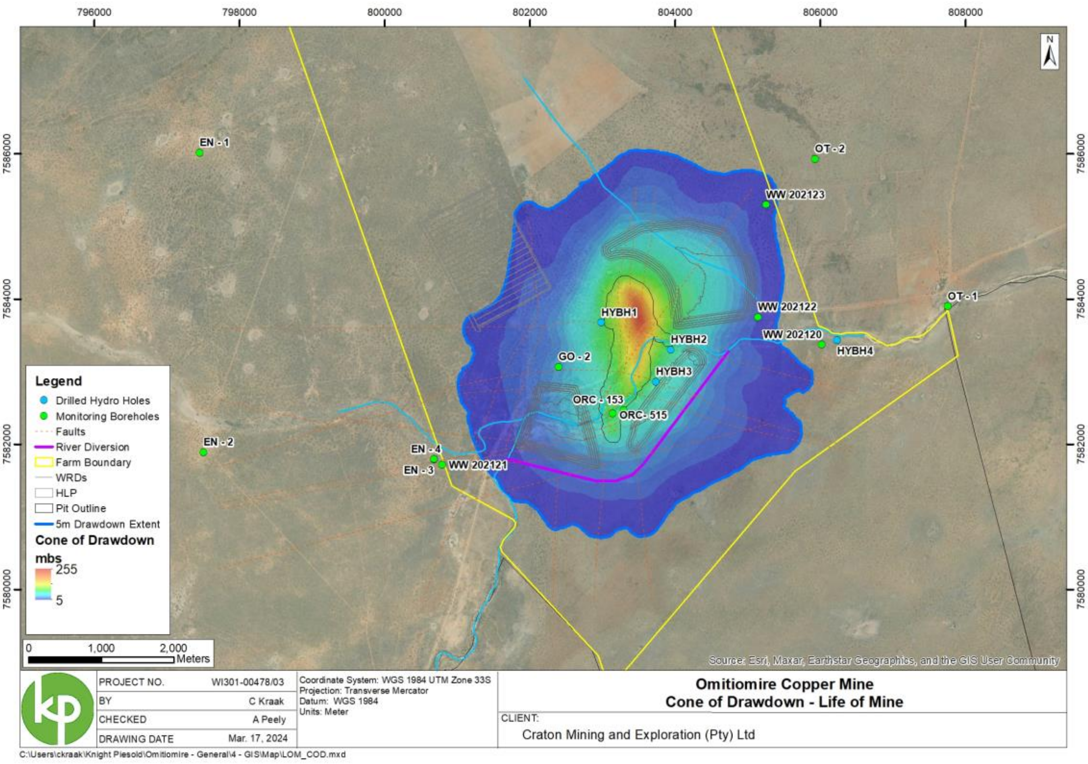


Figure 9-9: Cone of Drawdown at Life of Mine.

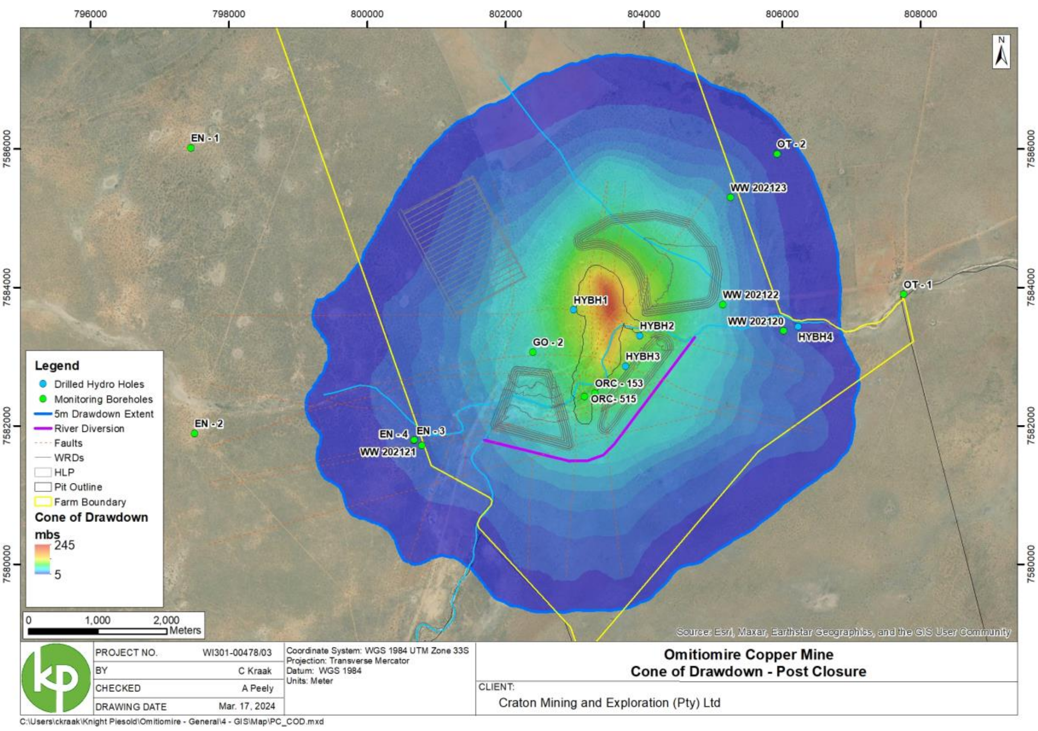


Figure 9-10: Cone of Drawdown at 50 years Post Closure

The mining operation is excavated almost daily, but the current numerical modelling assumes an annual time step for the pit design, which results in unstable hydraulic behaviour of the model. The model should include monthly pit designs and time steps for the results to be more accurate.

At the beginning of each year, the total excavated volume is deactivated, resulting in a spike in pit inflows. However, the inflow gradually decreases due to storage removal, and the hydrogeological system stabilises until the following year's pit design (Figure 9-11). The maximum inflow each year is the sum of seepage water during mining. The more realistic cumulative pit inflow each year is the transfer flow value at the end of that year plus the value in the same period in the previous years, as shown in Figure 9-12. It must be noted that this transfer flow is likely the minimum pit inrush that happens, and the transient inflows must be added to this for dewatering plans.

Based on these findings, the groundwater inflow rates into the pit are relatively low over the LOM at around 690 m^3/day and can be managed from passive dewatering by in-pit sumping.

These inflow rates do not account for direct precipitation and runoff into the pit (if stormwater control is not implemented), nor do they consider evaporation from the pit walls. If a significant water-bearing structure is intercepted, higher inflows could also temporarily occur until the structure has dewatered, which must be managed from the in-pit dewatering. The dewatering sump pump-out reticulation design should include a contingency allowance to ensure that the pit is not flooded due to extreme rainfall events or unanticipated inflows from structures.

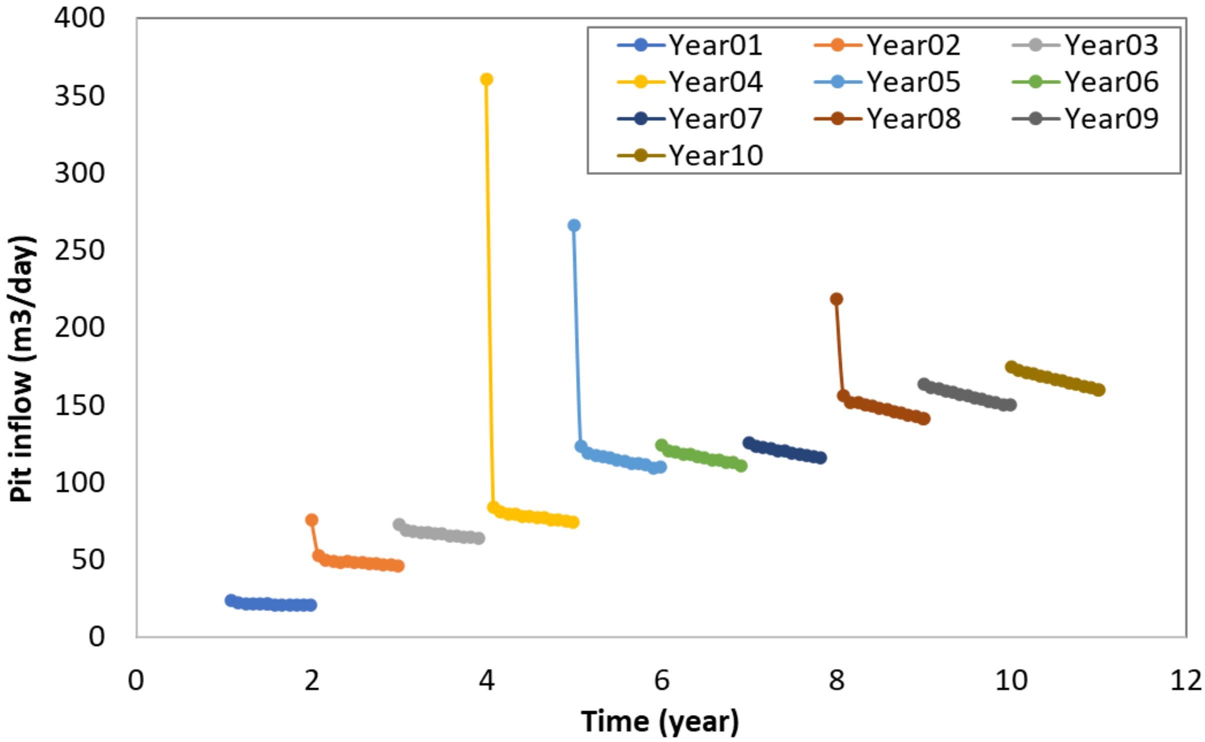


Figure 9-11: Pit inflows for the yearly time step as per the 10-year mine pit plans.

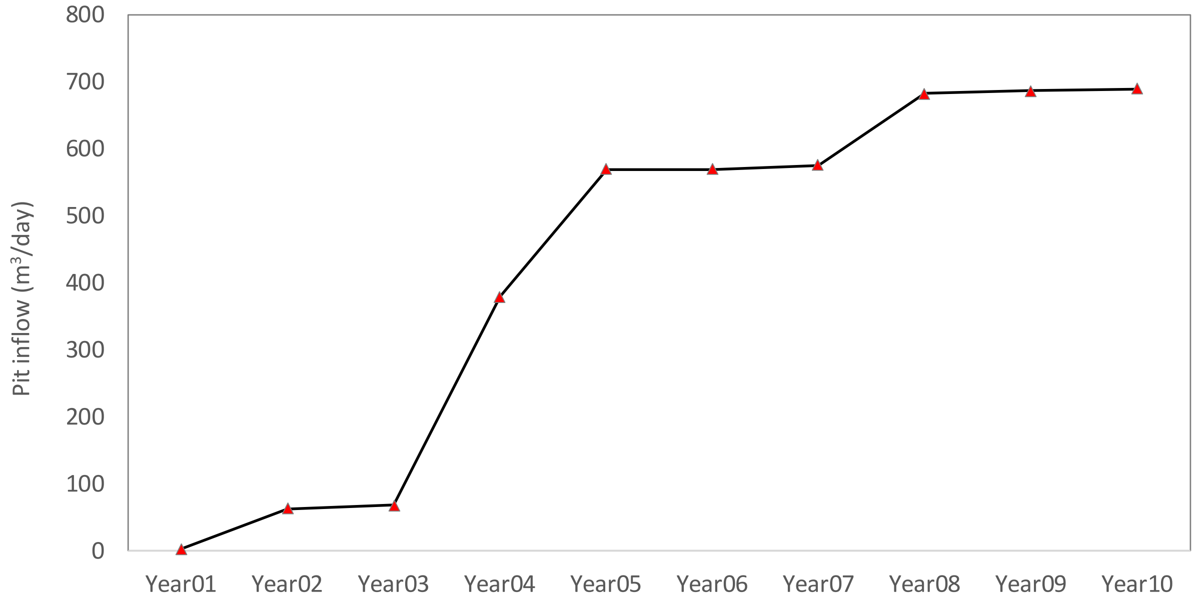


Figure 9-12: Cumulative pit inflows (transfer flow) over the 10-year mine pit plans.

9.6.4 DEWATERING WELLS

Active dewatering from dewatering wells around the pit was simulated to determine if they could have any effect in lowering the water table ahead of mining with the advantage of reducing pit inflows that will be impacted by mining in terms of water quality i.e. higher nitrates expected from blasting, fuel and diesel spills and possibly elevated sulphate (although the bulk of the fresh ore is chalcosite (CuS) with minimal pyrite (FeS_2)).

Four active pumping wells were hypothetically installed in layer 22, at an elevation of 1635m, along structures where there is a greater chance of active and saturated groundwater flow into the mine pit. The pumping rate of these wells was set to 0.3 L/s to observe the impact of vertical dewatering wells on the hydraulic head. As shown in Figure 9-13, the eastern and northern wells had a more significant effect than the western and south wells.

The simulation showed that the dewatering wells had only a small effect on the pit inflows and would likely not be necessary.

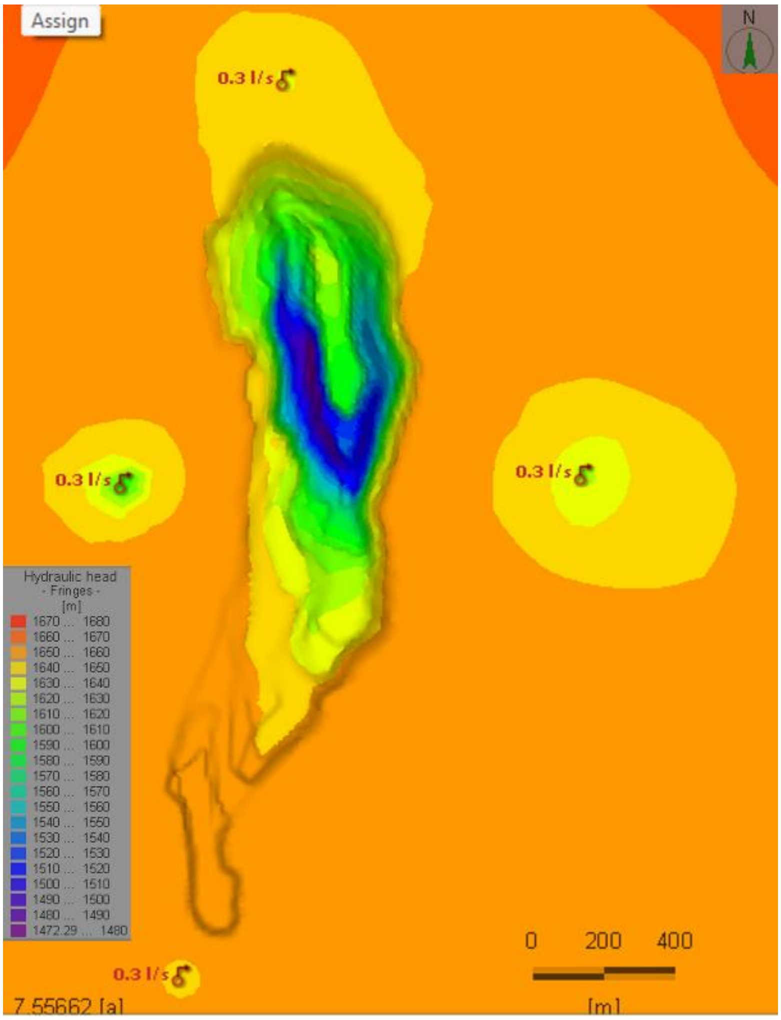


Figure 9-13: Dewatering vertical wells impact on the hydraulic head.

9.7 SOLUTE TRANSPORT SIMULATION

According to the geochemical analysis kinetic testing of the heap leach residue, the highest concentration of noted potential contaminants was 17.91 mg/l for Cu, 2.00 mg/l for Fe, and 0.60 mg/l for Ni. Copper was chosen to be simulated as a worse-case scenario and was given a dispersivity of 1000 m and a transverse dispersivity of 100m.

All facilities were simulated as unlined, to simulate the worst-case scenario. This model represents only dilution and dispersion of the contaminants and excludes any chemical or biological reactions.

The vertical migration is noticeable because of the hydraulic force induced by the pit's drawdown cone. After the first 10 years, the solute reaches the saturated zone but will likely not migrate downstream considerably because of the pit capture zone. The maximum horizontal and vertical migration after 35 years post-closure for Cu with 1 mg/l concentration is 370 and 245 m, respectively. Although there is a 100 m possible migration of the solute in the saturated zone, the maximum concentration simulated does not exceed 2 mg/l. Once the solute enters the fractured aquifer, it gets drawn into the pit.

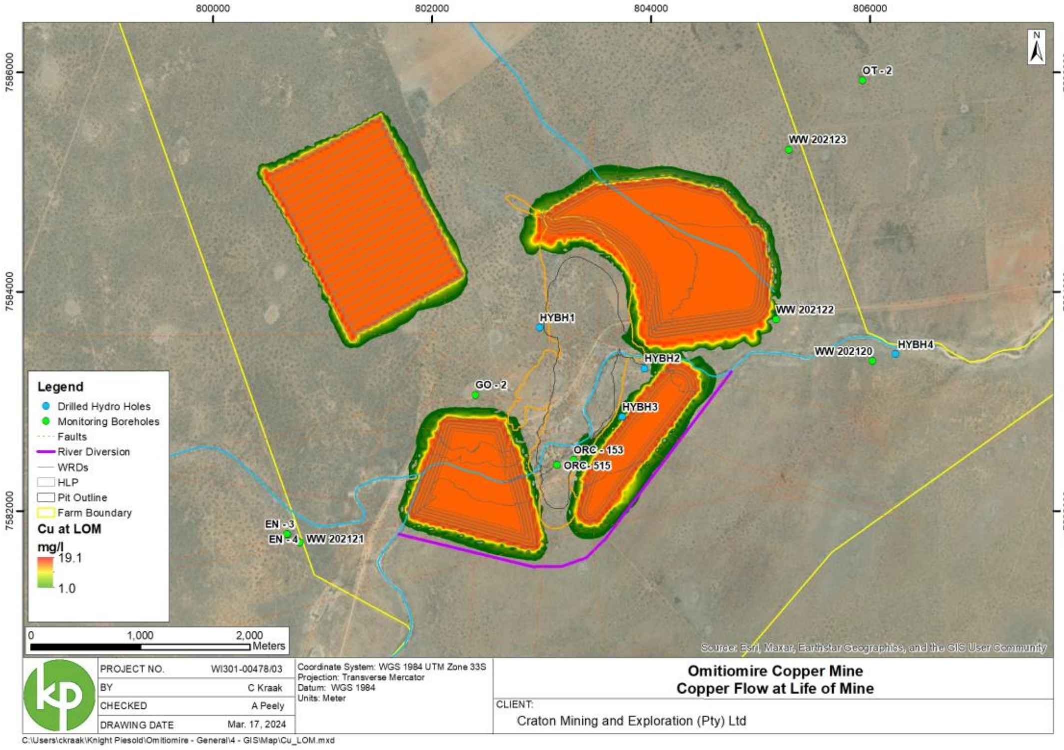


Figure 9-14: Cu mass transport at Life of Mine

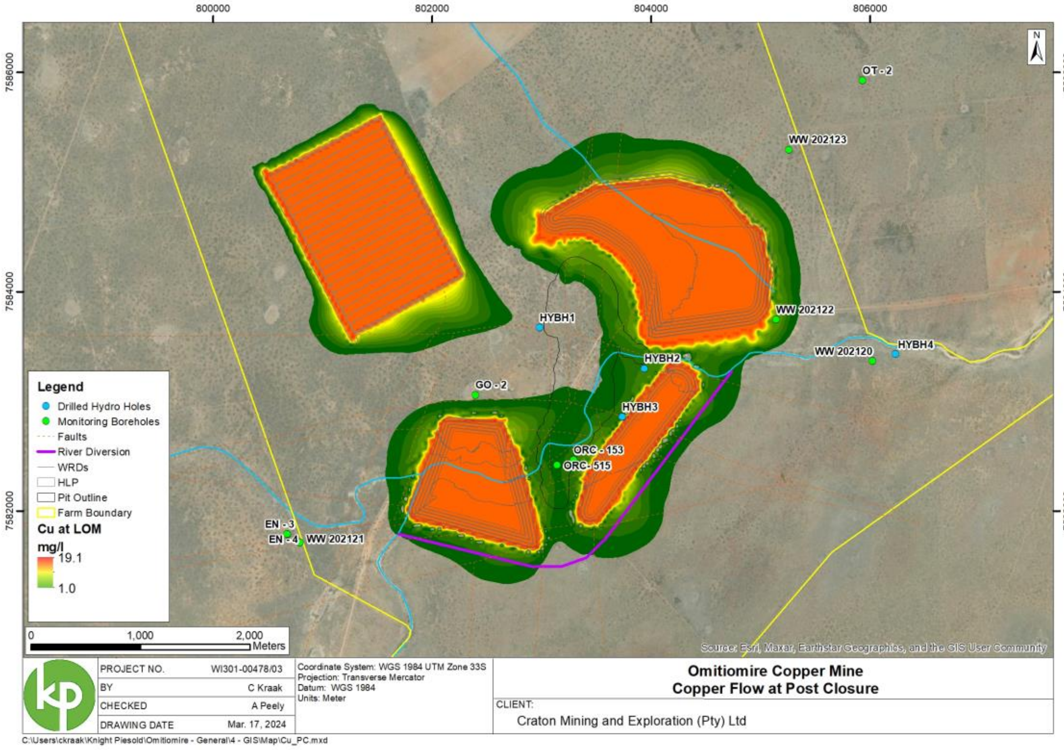


Figure 9-15: Cu mass transport in year 50.

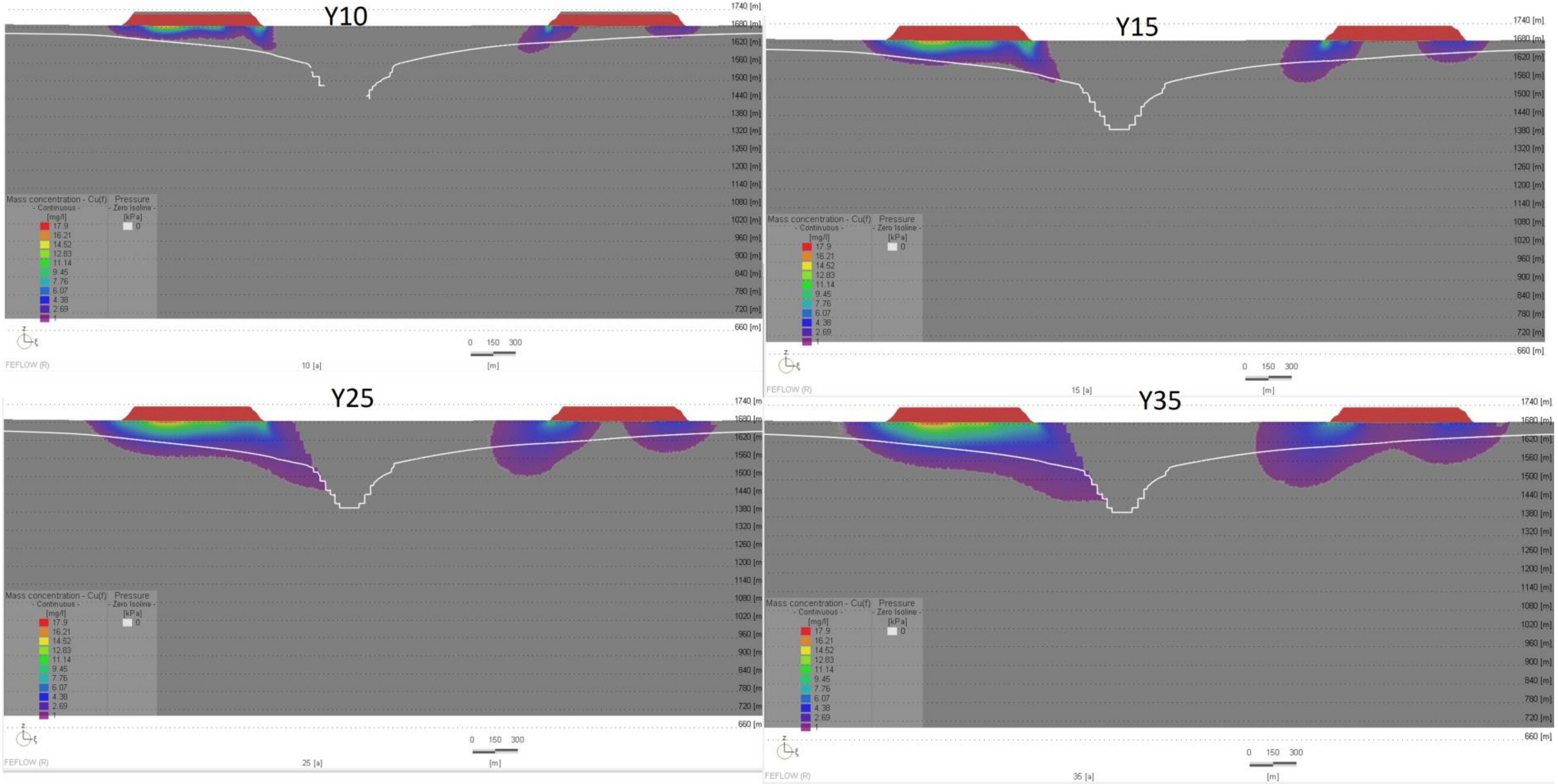


Figure 9-16: Cu concentration under the northern WRD in four years 10, 15, 25 and 35.

10.0 RISKS AND OPPORTUNITIES

- Low confidence in the recharge values reduces the overall confidence of the model. Rainfall water quality can assist in the determination of a more accurate recharge rate for the aquifers. It is recommended that rainfall samples be collected each season based on availability to provide higher accuracy recharge values.
- Rainfall in the region is sporadic and results in episodic time-based recharge to the groundwater and can impact inflow calculations in the model. It is recommended that daily rainfall events and volumes are recorded.
- The risks associated with groundwater in the region are minimal, with low inflow volumes and limited solute migration from the waste facilities. Quickflow from the waste rock dumps and runoff are excluded from the model outputs but could impact the Nossob River downstream of the mining infrastructure.
- Flooding of the pit after high rainfall events.
  - The low inflows that need to be managed (excluding direct rainfall and surface runoff into the pit) can be managed by in-pit sumping.
  - A contingency allowance in the event of high precipitation should be considered in the mine water reticulation from the pit.
- Transient high pore pressures after high rainfall events or intercepting a water bearing structure with high permeability and storage which may result in a temporary increase of inflows into the pit.
  - Installation of dewatering wells at targeted locations can mitigate the possibility of transient high pore pressures in the pit walls following rainfall events, particularly where the riverbed was before the diversion (with alluvials) is intercepted in the pit high walls or close to the pit walls.
  - In-pit horizontal drain holes installed locally during mining can be installed in areas of geotechnical weakness and/or high pore pressures to allow for the controlled dewatering of the area.
  - Vibrating wire transducers (VWTs) should be installed to monitor the seasonal pore pressure in different hydrostratigraphic units pre-mining to establish baseline conditions and during operations to monitor the impact of mining infrastructure, i.e. as the WRDs develop.
- The local water supply is limited, and it has been planned that the supply for the mine will be brought in from outside of this catchment. However, a few existing boreholes can supply small volumes to supplement the water supply.
  - Abstraction of the groundwater before it is exposed to contamination can be used to supplement the mine water supply.
- Solute migration from the mine waste facilities will move down-gradient. The installation of monitoring boreholes and piezometers is required, particularly on the original riverbed.
  - The monitoring wells can also act as scavenger wells should solute be picked up in the wells.
- The model predictions indicate that a limited extent to the cone of drawdown which is unlikely to impact the farmers boreholes. However, unknown structures may increase the extent of the COD.
  - Regional groundwater monitoring should continue to monitor the COD extent and be used to update the model in real time, increasing the model’s confidence.
- The river diversion provides an opportunity to divert fresh water around the mine infrastructure.

11.0 CONCLUSIONS

The proposed Omitiomire Copper Mine is in the Ekuja Basement Dome, which comprises alternating gneiss and amphibolite units. The aquifers in the area include the weathered rock associated with the alluvial deposits from the ephemeral Black Nossob River and the deep fractured rock aquifer.

The current groundwater regime indicates that baseflow to the river is minimal (losing river) and would only become a gaining river for short periods during and after flooding events, after which the river will revert to a losing river. In addition, the infrequent storm events that result in flow in the river are short-lived and provide minimal recharge to the groundwater.

The river diversion may locally reduce recharge volumes to the groundwater. However, this impact will be offset by the enhanced recharge from the WRDs.

The deep fractured aquifer is dominated by secondary flow with intermediated permeability and low primary permeability. Faults and fractures are the main groundwater conduits contributing to pit inflows. Inflow rates to the pit are low, reaching a cumulative 690 m^3/day by the end of LOM. This value does not consider evaporation from the pit walls, direct rainfall and overland flow into the pit. Based on the low inflow rates and high evaporation in the area, it is unlikely that any active out-pit dewatering boreholes will be necessary, and the water can be managed by passive dewatering from in-pit sumping.

If localised seepage occurs from structures or transient high pore pressures due to seepage from the WRDs following storm events, horizontal drains from in-pit benches can be installed where needed.

The COD created by the pit extends laterally, with a distance from the pit from 1 to 3.5 km and a 5 m drawdown by the LOM. The maximum extent of the COD is along the structures, and its influence is visible, particularly in shallow weathered aquifers. After closure, the pit will continue acting as a regional sink and draw groundwater and potential contaminants towards the pit. The COD, 50 years after post-closure, extends to a maximum of 4.5 km from the pit centre and does not reach the Nossob River.

Although the Geochem testing indicates low metal loading from the WRD, a copper value derived from the HLP testing was used to simulate the worst-case scenario. The maximum horizontal and vertical migration after 35 years post-closure for Cu with 1 mg/l concentration is 370 and 245 m, respectively. Although there is a 100 m possible migration of the solute in the saturated zone, the maximum concentration simulated does not exceed 2 mg/l. Once the solute enters the fractured aquifer, it gets drawn into the pit.

12.0 RECOMMENDATIONS

The following recommendations are provided to further the confidence level in the hydrogeological model and impacts for the Omitiomire Copper Mine:

- Dedicated piezometers, including open hole and vibrating wire transducers, should be installed targeting the alluvium aquifer and the hard rock aquifer separately to monitor pre-mining seasonal changes and during operations.
  - Documenting comprehensive information about boreholes, including installation depths and geological and structural conditions, is essential. This information is necessary for measuring the borehole groundwater level or pore pressure.
- Global circulation models and a downscaling approach should be used to project precipitation in the future to calculate recharge based on climate change scenarios.
- Double-ring infiltrometer tests should be conducted in several parts of the project, including the WRDs, to determine the recharge coefficient.
- Additional drilling and test pumping of targets in the schists is recommended to increase confidence in the hydraulic parameters.
- Obtain geotechnical logs and structural studies for the mine focusing on water-bearing faults and joint sets to incorporate into the model.
- Packer testing or a borehole magnetic resonance (BMR) downhole survey is suggested to refine the hydraulic parameters of structures that intercept the pit walls.
- Establish robust stormwater management around the pit to prevent flooding during high-intensity rainfall events.
- Update the numerical model with the additional information obtained from the recommendations.

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1. CERTIFICATION

This report was prepared and reviewed by the undersigned.

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Approval that this document adheres to the Knight Piésold Quality System: CK

APPENDIX 1

KP Field Report 2023

18 pages

Appendix A – Geophysics Report
Appendix B – Fieldwork SOP
Appendix C – Borehole Logs and Certificates
Appendix D1 – ECC Hydrocensus and Water Levels
Appendix D2 – KP Hydrocensus and Water Levels
Appendix E1 – Falling Head Test AQTESOLV Plots
Appendix E2 – Slug Test AQTESOLV Plots
Appendix E3 – Pumping Tests Step Test Plots
Appendix E4 – Pumping Tests Cooper Jacob Straight-line Plots
Appendix E5 – Pumping Tests AQTESOLV Plots

APPENDIX 2

Water Quality Results Lab Certificated

25 pages

APPENDIX 3

Isotope Results Lab Certificate

3 pages