OPEN PIT EXPANSION AREA 3 GEOHYDROLOGICAL SPESIALIST INPUT

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To: Environmental Impact Management Services (EIMS)

Subject: Open Pit Area 3 expansion – Geohydrological Study

Date: 3 November 2025

1. BACKGROUND

Hydrogeek Consulting was appointed by Environmental Impact Management Services (Pty) Ltd (EIMS) to undertake a geohydrological impact assessment for the proposed pit expansion in Area 3 of the Rustenburg Chrome Mine (RCM). This specialist study has been prepared as part of the Basic Assessment Report (BAR) to support environmental authorisation for the proposed project.

The purpose of this assessment is to establish a clear understanding of the groundwater conditions and potential impacts associated with the Area 3 pit expansion. The study evaluates baseline groundwater levels and quality, identifies historical and current mining-related influences, and assesses potential impacts on groundwater flow and quality resulting from the proposed activities.

It should be noted that a comprehensive, site-wide geohydrological study is currently being undertaken as part of the broader Environmental Impact Assessment (EIA) process for Rustenburg Chrome Mine. The present BAR therefore focuses specifically on Area 3, with findings and recommendations aligned to the overall groundwater management framework being developed for the mine.

It should also be noted that the underground mining from area 3 is not assessed as part of this scope and the focus was on the impact from mining up to 2031 Life of Mine (LOM) for area 1-3 opencast. However, since limited information exists in determining the impact for the closure and post-closure phases and the impact from underground mining, various recommendations for determining, mitigating, managing and monitoring of the impacts and risks are provided.

Through the integration of available hydrogeological data, site investigations, and conceptual interpretation, this assessment provides a targeted and defensible framework to inform decision-making and guide mitigation and monitoring measures for the sustainable management of groundwater resources within the Area 3 expansion zone.

2. Objectives

The main objective of this geohydrological impact memorandum is to assess the potential groundwater impacts and recommend mitigation measures associated with the proposed expansion of the opencast pit (Area 3) at Rustenburg Chrome Mine (RCM). The memorandum provides site-specific input to the Basic Assessment Report (BAR) and complements the ongoing site-wide geohydrological study being undertaken as part of the Environmental Impact Assessment (EIA) for RCM.

2.1. Locality of the Study Area

Rustenburg Chrome Mining (Pty) Ltd (RCM), previously known as Lanxess Chrome Mine (Lanxess), is located north-west of Pretoria. RCM is located ~7 kilometres (km) east of Kroondal and ~20 km south-east of Rustenburg and falls within the Bojanala Platinum District Municipality, North West Province.

The existing operation consists of:

- Tailings Storage Facilities (TSF)
- Waste Rock Dumps (WRD)
- Dams
- Stockpiles
- Concentrators
- Landfill Sites
- Underground and Opencast mining
- Shafts

2.2. Regional Drainage and Surface Topography

The project area falls within the Crocodile West and Marico Water Management Area (WMA), quaternary catchment A22H. The A22H quaternary catchment area is 579 km^2 and has a MAR of 14.07 million m^3. Runoff emanating from this quaternary catchment drains in a north–easterly direction via the Hex River. Elevations in the A22H quaternary range from 1220 meters above mean sea level (mamsl) at the highest point within the catchment and drop to 1112 mamsl at the outlet of the catchment.

Surface drainage at the Rustenburg Chrome Mine site occurs mainly towards the west in the direction of the Hex River. Runoff is taken by two tributaries which flow towards the west into the Hex River, of which one of the tributaries originates at the RCM site. The elevation of this area ranges from 1130 mamsl to 1150 mamsl. Surface drainage at the area occurs mainly towards the South, directly into the Sandspruit as this site is situated approximately 1 km from the Sandspruit.

The main water course in the A22H quaternary catchment is the Hex River found on the western side of the project area; this river joins the Elands River which is a tributary to Crocodile River.

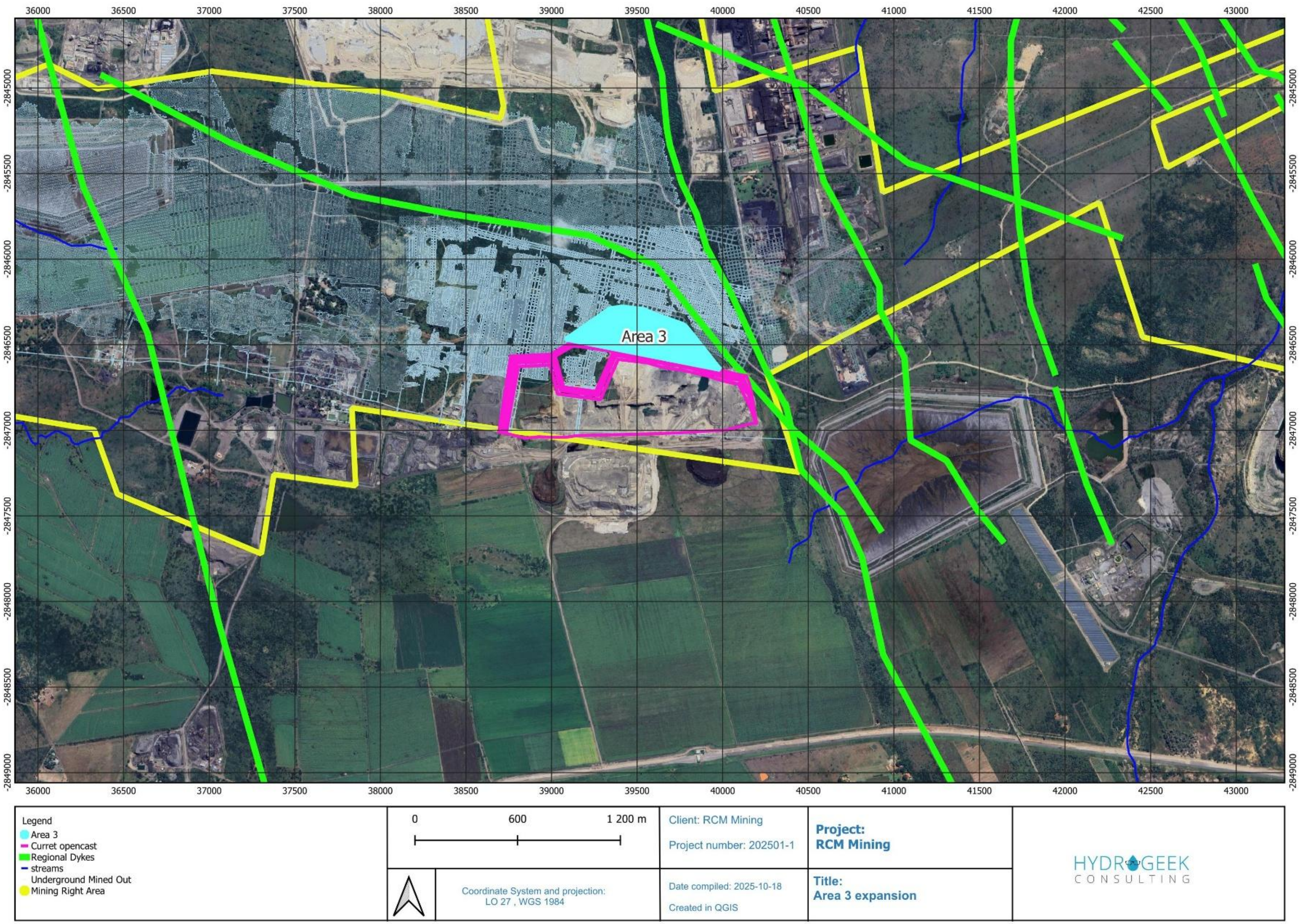

Figure 1 Mine infrastructure layout Area 3 expansion

2.3. Rainfall and Cumulative Rainfall Departure (CRD)

The study area is located within the middle-veld climatic zone, characterized by hot summers and mild winters. The Regional Mean Annual Precipitation (MAP) in the area typically varies, with an average annual rainfall of approximately 633 mm. Precipitation predominantly occurs during the summer months, in the form of high-intensity, short-duration thunderstorms. These storms are most frequent between November and March, with the peak rainfall typically recorded in January.

To evaluate the local rainfall patterns, daily rainfall data was sourced from the Computing Centre for Water Research (CCWR) database, University of Natal. Specifically, the data from CCWR gauge 0511672, located 4 km northwest of the mine at Klipfontein, was utilized. The provided records span 73 years of recorded and patched daily data, offering a comprehensive dataset that is representative of the rainfall conditions at the mine site. The long-term dataset allows for robust analysis of historical rainfall trends and provides a solid foundation for hydrological modeling and water management strategies in the region (Table 1).

This rainfall data is crucial for understanding the temporal distribution and intensity of precipitation events, which can impact both surface and groundwater dynamics in the area. The information will aid in assessing water inflows, potential flood risks, and formulating effective dewatering strategies, which are essential for ongoing mine operations and environmental management.

Table 1 Average rainfall and evaporation (Minelock, 2022)

Month	Average rainfall (mm)	Average evaporation (mm – S-Pan)
January	117	182
February	91	152
March	80	147
April	46	116
May	16	99
June	8	81
July	4	90
August	5	119
September	16	160
October	52	186
November	82	176
December	116	192
Mean annual	**633**	**1 700**

Figure 2 shows the average amount of rainfall per month in Kroondal (Northwest). The numbers are calculated over a 30-year period to provide a reliable average.

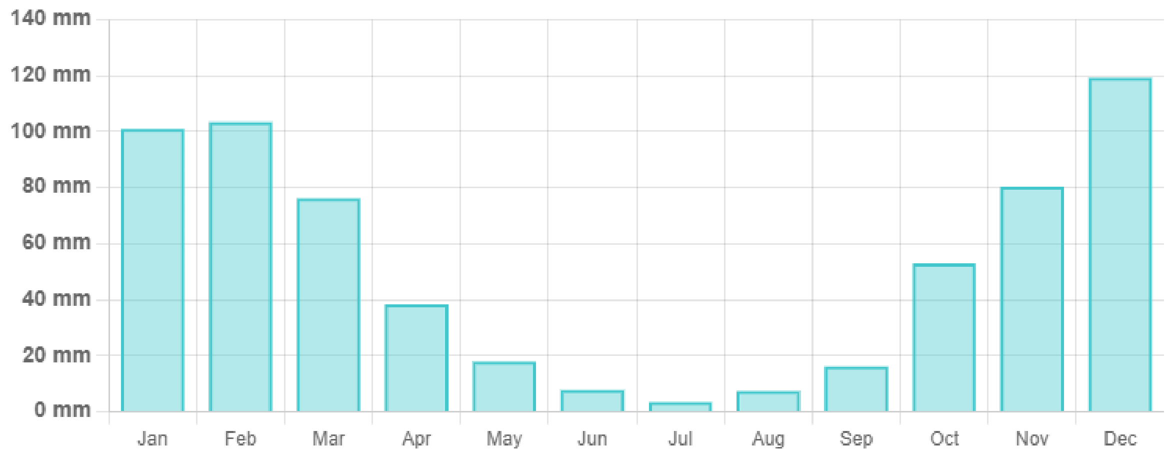

Figure 2 Climatic data representation.

The CRD is a graph that is constructed by accumulating the monthly differences between a specific monthly rainfall and the average monthly rainfall of the rainfall sequence. Increasing CRD trends are therefore indicative of consecutive above average rainfall events (probably causing groundwater recharge and therefore rising water levels) whilst decreasing CRD trends are indicative of consecutive below average rainfall events with no or very little groundwater recharge and therefore declining water levels.

2.4. Evaporation

The proposed development is in Evaporation Zone 3B. The closest Evaporation station A2E008, the Rustenburg station, is located 8km East of the proposed development, and gives a mean annual evaporation (MAE) of 1645mm for the S-Pan value and 2054mm for the A-Pan value. The evaporation measurements cover the years 1957 to 1979.

3. GEOLOGY OF THE STUDY AREA

3.1. Regional Geology

The regional geology of the area is given in Figure 3 and Figure 4 he regional area is underlain by the Ruighoek pyroxenite, Mathlagame norite, Mathlagame norite anorthosite and Kroondal Norite of the Rustenburg Layered Suite, Bushveld Complex, Vaalian Era. The soil cover on the site consists of a dark brown to black, firm loamy clay with abundant vegetation roots. This soil is dispersive and expansive and forms large cracks when moisture is driven off. Locally the soil is referred to as black “turf”.

Generally, it should be noted that the geology of site has been artificially modified in areas due to mining activities surrounding the site. This artificially modification of the geology could possibly have an impact on the hydraulic properties of groundwater flow in the subsurface. A simplified description of the units underlying the project area is represented.

The ore body is in the Critical zone of the Rustenburg Layered suite in the Bushveld Ingenious Complex (BIC). The area strikes east-west and dip10 degrees to the north. The chrome layers are interlayered by pyroxenites, norites and anorthosites.

The faults are predominantly dextral, many of which have later been intruded by dykes. The majority of the dykes have a north-north-west strike and form part of the Pilanesberg dyke swarm. A major dyke flanks the western portion of the project area and is associated with a major fault in the area and constitutes the most noticeable topographic feature. This syenite dyke dips to the east and forms a no-flow groundwater boundary.

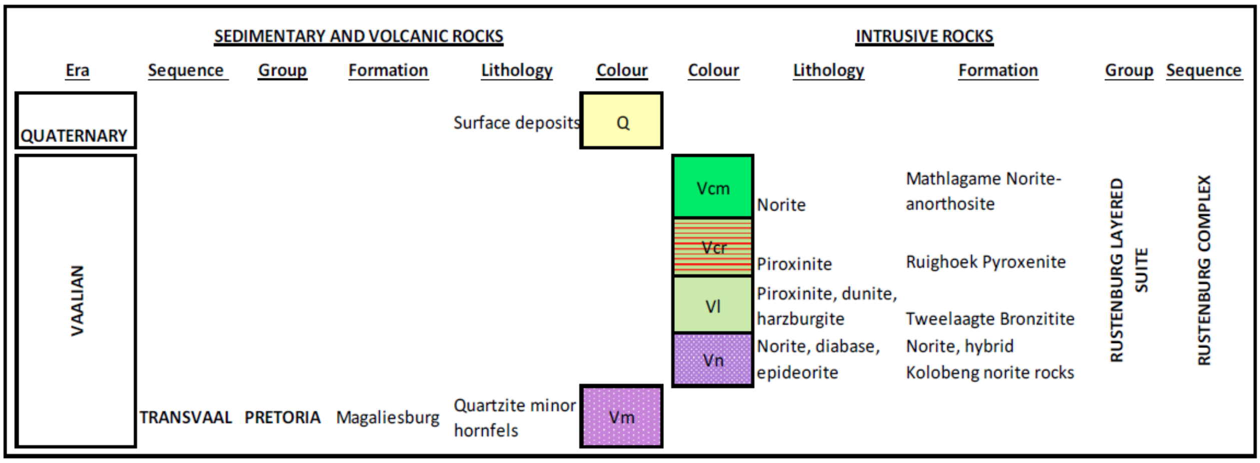

Figure 3 Geology groups present

3.2. Structures

Regional Dykes (green lines): Multiple linear intrusions transect the lease area in a NE–SW and NW–SE orientation. These structures may influence groundwater movement, compartmentalisation, and ore body continuity. Dykes may act as barriers or conduits for groundwater, influencing pit inflows and water balance modelling.

Central mining blocks (Area 3) fall largely within a homogenous lithological zone (Mathlagame Norite–Anorthosite), supporting more predictable geotechnical and hydrogeological conditions.

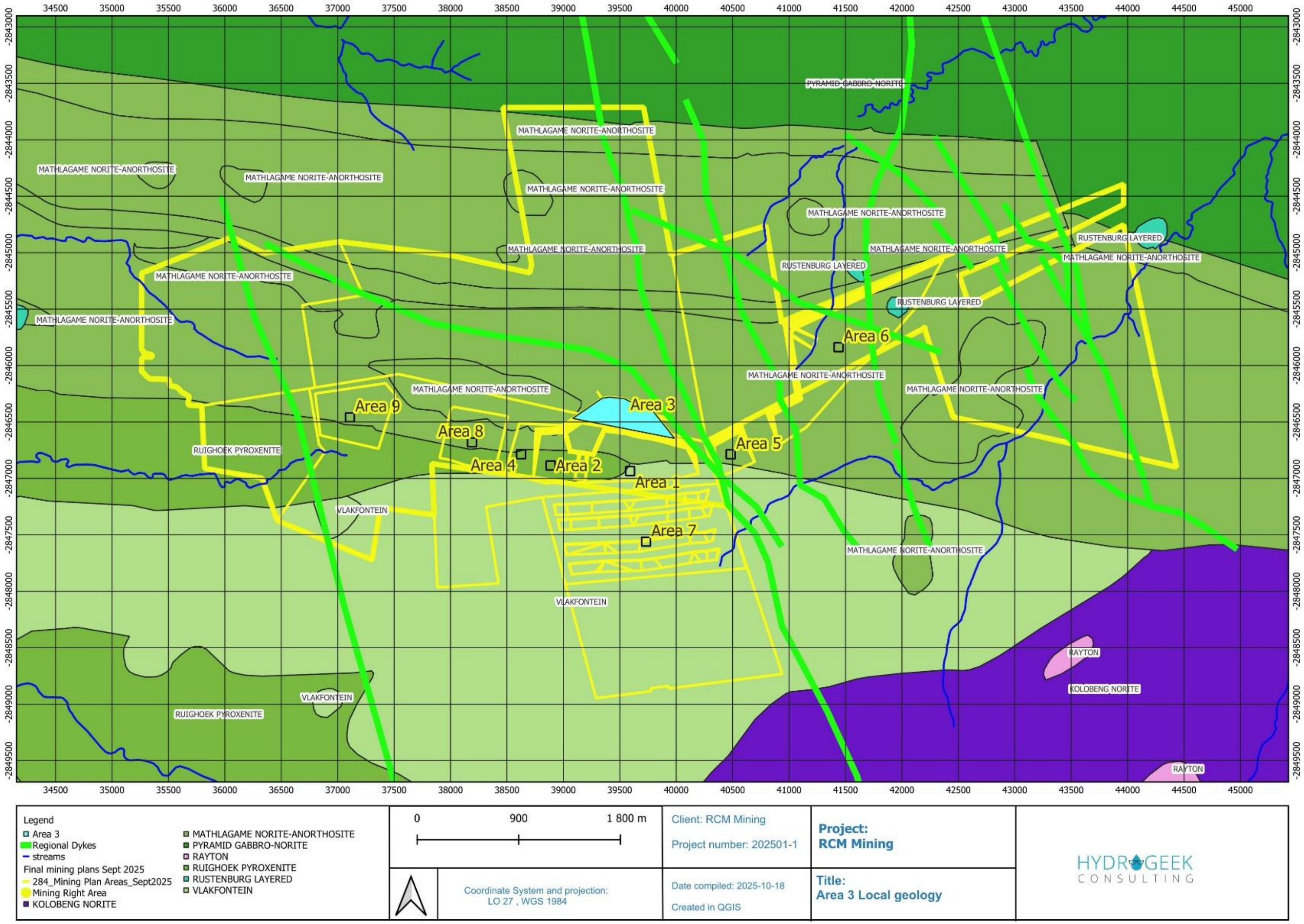

Figure 4 Local Geology (Areas 1 to 9 (long-term planning), Area 3 current application).

4. Mining

The figure below presents the topographic surface of the proposed Area 3 pit expansion. Elevations range from approximately 1,120 mamsl (blue) in the lower-lying zones to 1,240 mamsl (red) at the highest points. The Area 3 expansion occurs along the northern of the existing open pit.

Potential link to the future underground from this area needs to be confirmed as this will affect the closure scenarios and future abstraction requirements of this pit.

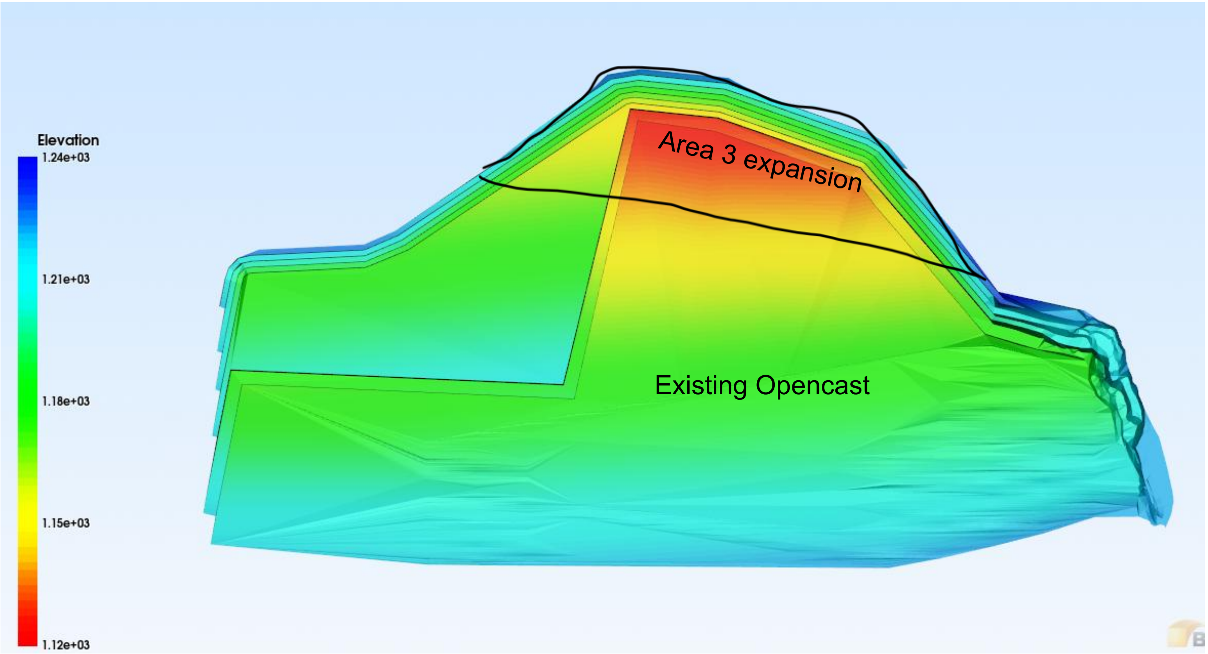

Figure 5 Area 3 expansion

The final mining plan (Sept 2025) highlights nine mining blocks (Areas 1–9), all contained within the mining right boundary.

- Areas 1–7: Centrally clustered, suggesting contiguous ore zones.
- Area 6: Eastern extension, close to the Rustenburg Layered lithologies.
- Areas 8 & 9: Western blocks, partly overlapping regional dykes and Rughoek Pyroxenite margins

The long term planned pit development sequence includes phased operations between 2025 and 2035, with each pit associated with a designated Hanging Well (HW**)** depth that will serve as the reference for the final pit depth. Pit 1-4 (of which Area 3 is a part of) is scheduled to start in 2026, progressing to a final depth of 127 m, with mining concluding by July 2031. Pit 5, a relatively short-lived operation, will be developed from January to July 2028, reaching a final depth of 60 m. Pit 6 is the deepest of the sequence at 140 m, commencing in August 2028 and continuing until July 2038. Pit 8 will extend to 94 m, operating between August 2031 and August 2033, while Pit 9, with a final depth of 82 m, is planned to run from October 2033 to June 2035**.**

The staged sequencing of these pits, with varying final depths, demonstrates a strategic progression of mining areas that ensures continuous production and allows for resource scheduling around depth target

Table 2 Pit plans 2025-2038

Pit	Final HW (m)	Start	End	Duration (days)	Duration (months)	Duration (years)
Pit 1-4	**127,0**	**2022/01/01**	**2031/07/31**	**3498,0**	**116,6**	**9,7**
Pit 5	60,0	2028/01/28	2028/07/31	185,0	6.0	0,5
Pit 6	140,0	2028/08/01	2038/07/01	3621,0	119.0	9,9
Pit 7	12,0	2031/08/01	2031/12/31	120,0	4,0	0,3
Pit 8	94,0	2031/01/01	2034/01/01	1096,0	36,5	3,0
Pit 9	82,0	2033/10/01	2035/06/01	608,0	20.0	1,7

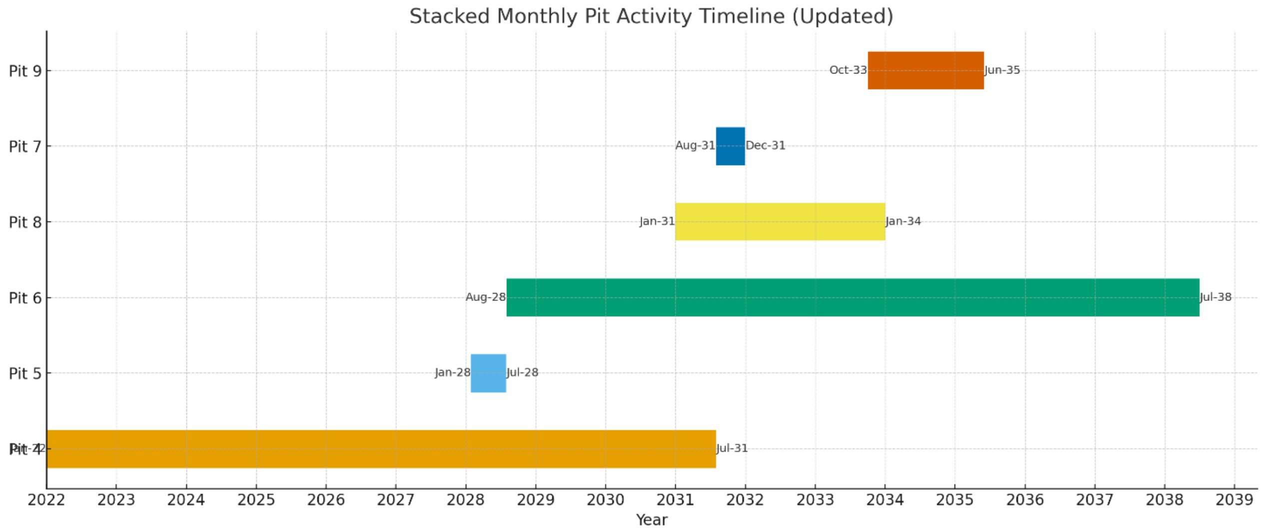

Figure 6 Pit Timeline

With the focus on Area 3, which is the expansion of the current pit towards the north. The impact of the pit 5 and pit 6 will also affect the groundwater.

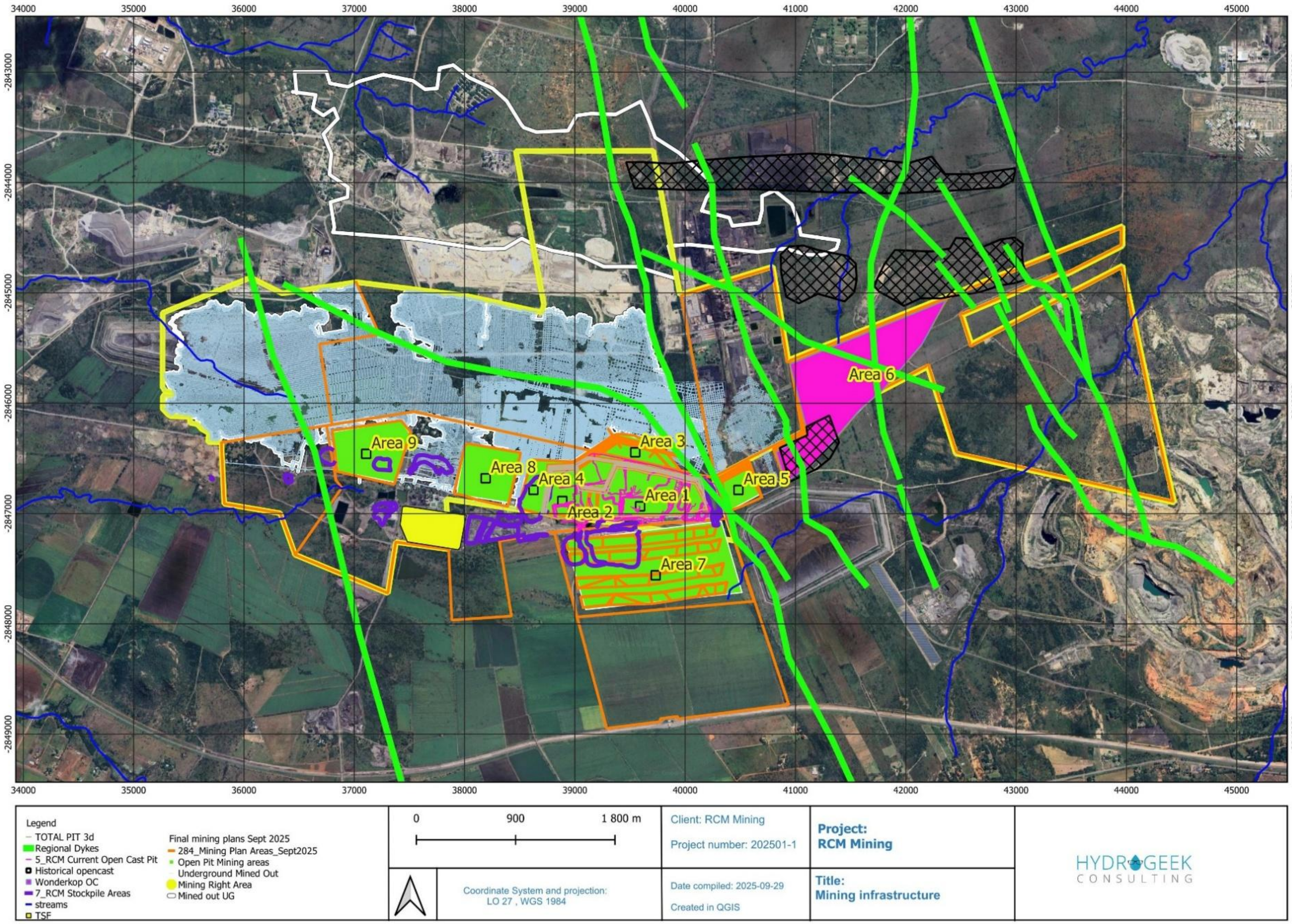

Figure 7 Current mining application and long-term mining activities to be applied for

5. Hydrogeology

The hydrogeological setting of the proposed Area 3 pit expansion is characterised by a dual aquifer system consisting of a shallow saprolitic aquifer developed in the weathered zone and a deeper fractured bedrock aquifer associated with the Rustenburg Layered Suite. Area 3 lies within a structurally complex hydrogeological environment, with localized high-permeability features (dolerite) embedded within a generally low-yielding fractured system. Future pit inflows are likely to be moderate but could increase substantially where mining intersects dolerite intrusions. Additional targeted drilling, aquifer testing, and monitoring along the dyke corridor are recommended to refine inflow predictions and guide dewatering system design.

Shallow (Saprolitic) Aquifer

Recharge occurs primarily from rainfall infiltration through the unsaturated zone. Vertical percolation is dominant, with limited lateral flow. The weathered zone generally extends to depths of 9–25 m bgl, averaging ~15 m. Hydraulic conductivities vary significantly—from 10^{-8} m/d to 20 m/d, depending on lithology—while porosity ranges from 0.25 to 0.7. This aquifer represents the main reservoir for local recharge and is likely to contribute to early-stage pit inflows during excavation.

5.1. Fractured Bedrock Aquifer

Groundwater movement in the underlying fractured rock is controlled by secondary structural features such as faults, joints, and dykes. Water levels typically occur between 5 m and 40 m bgl, with low borehole yields of 0.1–2 L/s, indicating limited storage capacity. Hydraulic conductivities in this aquifer are typically 10^{-5} m/d, with porosities of about 0.05. Groundwater quality is moderate to poor, often showing elevated Ca–Mg–Cl–SO_4 concentrations and EC values between 4.4 – 120 mS/m.

5.2. Preferential Flow and Structural Controls

The hydrogeology is strongly influenced by dolerite and syenite dykes, trending mainly northeast–southwest and north–south. These structures act variably as barriers or conduits depending on fracturing. Field evidence indicates that dolerite-related structures are hydraulically active, showing measurable permeability and localised yields up to 1.5 L/s, while syenite-hosted fractures are poorly connected and mostly dry. Consequently, groundwater inflows to the planned pit are expected to be spatially variable, with higher inflow potential near dolerite zones intersecting the pit footprint. It is not expected that dewatering volumes from Area 3 will be significantly greater than the existing pit, and it would therefore, not affect the water balance of the mine significantly.

5.3. Water Strikes and Weathering:

Historic data indicate water strikes at 10–30 m bgl, corresponding to the base of the weathered zone. Average weathering depths of ~24 m support the conceptual model of a moderately deep, variably saturated profile.

5.4. Groundwater Levels

The proposed expansion of the existing opencast pit (Area 3) is situated within a hydrogeological setting dominated by a shallow, topography-driven groundwater system. According to the Digby Wells Groundwater Specialist Study (2015), regional groundwater levels are largely controlled by surface elevation and are only marginally influenced by underground mining activities. As such, groundwater levels below approximately 11 mbgl are considered representative of steady-state baseline conditions for model calibration.

Groundwater levels within and around the existing opencast pits remain largely unquantified due to the absence of dedicated monitoring boreholes. It is therefore recommended that targeted drilling and installation of piezometers be undertaken near the active and proposed pit areas to better characterise groundwater flow dynamics and potential pit inflows.

5.5. Depth to Groundwater, Piezometric Heads and Flow Directions

According to the Digby Wells Groundwater Specialist Study (2015), regional shallow groundwater levels are primarily influenced by topography and are less affected by underground mining activities. Consequently, groundwater levels below 11 meters below ground level (mbgl) can be used as a steady baseline for model calibration.

Recent data from the hydrocensus study conducted in February 2025 (Table 3 and Figure 8) shows that groundwater levels in the area range from 5.2 to 46.5 mbgl, with an average level of 16.43 mbgl. The deeper groundwater levels (>30 mbgl) measured in boreholes BH19 and LANBH8 are associated with the underground workings, where groundwater is being abstracted. It can be assumed that these deeper groundwater levels are influenced by underground mining. In contrast, shallow groundwater levels (<8 mbgl) in boreholes LANBH13, BH16A, and LANBH6, located near the Tailings Storage Facility (TSF) and dams, are more likely to be affected by seepage from these facilities. These predictions will be validated through quality sampling.

It is important to note that groundwater levels around the current opencast pits remain unknown, as no boreholes have been drilled in these areas. To address this data gap, it is recommended to site and drill monitoring boreholes near the opencast mining areas to obtain a clearer understanding of groundwater behaviour in these zones. This information will be valuable for managing water resources and mitigating potential environmental impacts related to the opencast mining operations.

Table 3 Groundwater levels measured in hydrosensus, 2025

ID	x (LO27)	y (LO27)	Elevation	BH Type	Static Water level (mbgl)	Static Water level (mamsl)
WKG-12	40377.1002	-2845435.361	1202	Wonderkop	0,72	1201,28
WKG-6	40384.8855	-2845828.067	1209	Wonderkop	1,2	1207,8
WKG-11	40318.1925	-2845480.405	1204	Wonderkop	1,5	1202,5
WKG-17	40243.18	-2844380.966	1193	Wonderkop	1,5	1191,5
WKG-40	40639.4058	-2844703.677	1190	Wonderkop	1,75	1188,25
WKG-8	40642.51459	-2845372.149	1200	Wonderkop	2,53	1197,47
WKG-44	40600.9679	-2845666.171	1208	Wonderkop	2,55	1205,45
WKG-38	40708.7337	-2845116.857	1198	Wonderkop	2,57	1195,43

ID	x (LO27)	y (LO27)	Elevation	BH Type	Static Water level (mbgl)	Static Water level (mamsl)
WKG-18	40606.0619	-2844399.798	1192	Wonderkop	2,8	1189,2
WKG-37	40714.3563	-2845243.514	1200	Wonderkop	3,18	1196,82
WKG-3	40658.8943	-2845564.857	1205	Wonderkop	3,23	1201,77
WKG-49	41125	-2844365.005	1187	Wonderkop	3,28	1183,72
WKGR-3	40783.4096	-2845261.507	1199	Wonderkop	3,31	1195,69
WKG-48	41029.3348	-2844437.838	1187	Wonderkop	3,32	1183,68
WKG-5	40615.3263	-2845267.627	1200	Wonderkop	3,5	1196,5
WKG-39	40593.4481	-2844877.504	1198	Wonderkop	3,98	1194,02
WKG-47	40969.9994	-2844447.005	1187	Wonderkop	4,5	1182,5
WKG-8A	40643.5292	-2845371.853	1200	Wonderkop	4,53	1195,47
WKG-7	40124.6726	-2845824.086	1212	Wonderkop	4,6	1207,4
WKG-9	40778.5562	-2845403.687	1200	Wonderkop	4,65	1195,35
WKG-20	40593.1121	-2843505.537	1190	Wonderkop	4,69	1185,31
WKG-1	41085.7561	-2844403.88	1187	Wonderkop	5,24	1181,76
BH16A	36749.22181	-2846703.596	1200	Monitoring	5,44	1194,56
WKG-2	40793.767	-2844178.736	1188	Wonderkop	5,44	1182,56
WKG-36	40058.0274	-2845398.609	1205	Wonderkop	5,44	1199,56
LANBH6	37420.89978	-2847222.848	1210	Monitoring	6,5	1203,5
WKG-13	39922.7097	-2844773.056	1202	Wonderkop	6,8	1195,2
WKG-34	40173.3724	-2846119.746	1216	Wonderkop	7,4	1208,6
WKG-16	40728.185	-2844936.866	1199	Wonderkop	7,6	1191,4
WKG-22	41167.4205	-2844156.515	1184	Wonderkop	7,85	1176,15
WKG-25	40802.2153	-2846764.329	1219	Wonderkop	7,86	1211,14
WKGR-4	40750.3046	-2844969.683	1199	Wonderkop	7,9	1191,1
BH3	36988.64153	-2848971.282	1213	Production	8,5	1204,5
BH3	37393.23817	-2846997.652	1209	Production	8,7	1200,3
WKG-15	40239.9308	-2844961.964	1201	Wonderkop	9,39	1191,61
BH17	37931.53688	-2847475.897	1213	Production	9,4	1203,6
LANBH10	37155.68695	-2846757.575	1213	Monitoring	9,45	1203,55
LANBH9	37279.05284	-2846780.189	1206	Monitoring	9,9	1196,1
WKG-41	39826.7881	-2844212.831	1197	Wonderkop	9,9	1187,1
BH12A	36653.11792	-2846656.134	1198	Monitoring	10,4	1187,6
BH18	37826.76728	-2846952.685	1215	Production	11,7	1203,3
WKG-23	40874.8145	-2846342.811	1211	Wonderkop	12,28	1198,72
FH02	36630.92095	-2849237.836	1205	Open BH	12,7	1192,3
SC02	37237.95933	-2849508.963	1209	Production	13,5	1195,5
SC01	37334.12724	-2849490.068	1212	Production	13,9	1198,1
BH4	37072.44187	-2848891.529	1214	Production	15,11	1198,89
BH2	37189.02801	-2849070.333	1216	Production	15,42	1200,58
FH01	36708.65433	-2849101.341	1212	Open BH	15,5	1196,5
LANBH13	36811.26365	-2846910.938	1199	Monitoring	15,5	1183,5
WKG-24	40563.2403	-2846512.786	1218	Wonderkop	17,97	1200,03

ID	x (LO27)	y (LO27)	Elevation	BH Type	Static Water level (mbgl)	Static Water level (mamsl)
LANBH5	38031.61404	-2846939.867	1197,2	Monitoring	18,5	1178,7
BH1	37189.73073	-2848820.29	1214	Production	18,62	1195,38
WKG-14	40328.626	-2846609.162	1226	Wonderkop	18,92	1207,08
RP02	36550.60818	-2848855.844	1207	Production	20,6	1186,4
LANBH4	38399.79457	-2846800.12	1210	Monitoring	22,4	1187,6
LANBH8	37538.61237	-2846441.473	1195	Monitoring	31,9	1163,1
BH19	37409.84462	-2846198.598	1209	Production	45,3	1163,7
Average					10.34	1193,97
Max					45,30	1211,14
Min					0,72	1163,10

As expected in natural systems, groundwater levels generally follow the topography of the land surface. A scatterplot of groundwater levels versus surface elevation provides insight into whether any influences, such as mining activities or facilities, are affecting groundwater behaviour. If any groundwater levels have significantly decreased or increased beyond the expected trend, these would appear as outliers on the graph.

The scatterplot (Figure 10) shows a generally consistent relationship between surface elevation and groundwater level elevation, with an average alignment between the two. As surface elevation increases, the groundwater levels tend to increase as well, which is consistent with natural groundwater flow patterns. However, some outliers are observed above and below the trend line. These outliers correspond to boreholes that are either drilled into deeper underground workings or located near waste facilities, where groundwater may be influenced by mining activities or seepage from infrastructure such as tailings dams.

The presence of these outliers confirms the potential impact of underground mining and nearby waste facilities on groundwater levels, which warrants further investigation to understand the extent of their influence. Identifying and addressing these anomalies will help refine groundwater models and improve water management strategies, particularly in areas near mining operations and waste storage facilities.

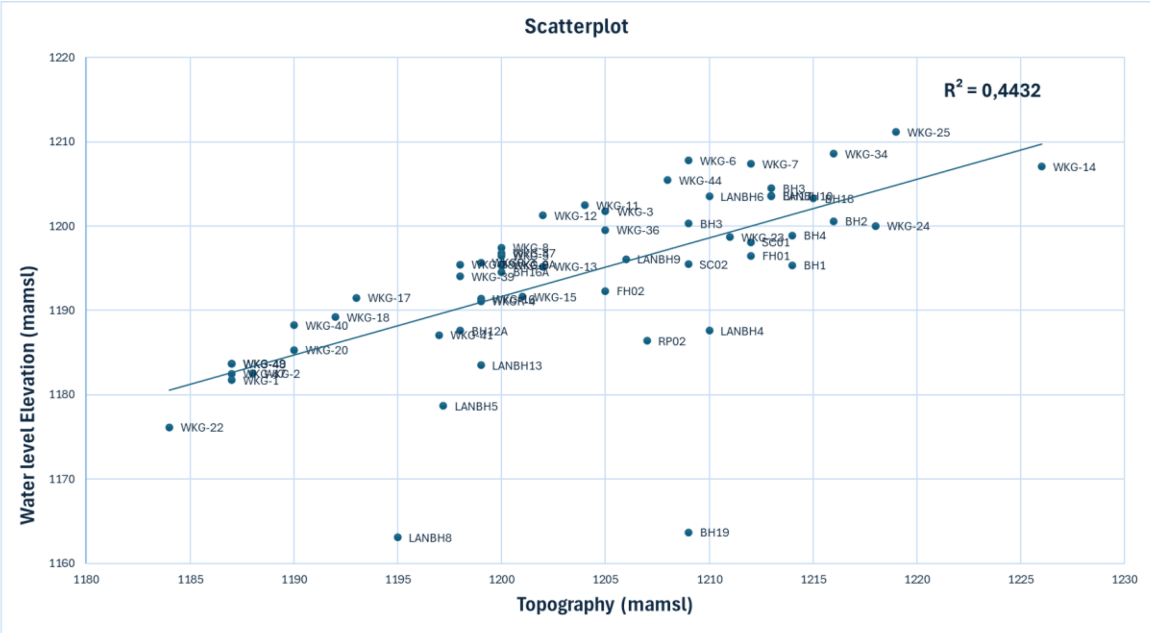

Figure 8 Scatterplot of groundwater boreholes: Surface Elevation vs Water Level Elevation

The general flow direction is towards the major drainage Hex River in the west (Figure 9 and Figure 10). Locally the groundwater flow directions are altered through abstraction from boreholes and potential seepages from waste areas. (Figure 9). Most of the data available are located in the eastern part of the mine.

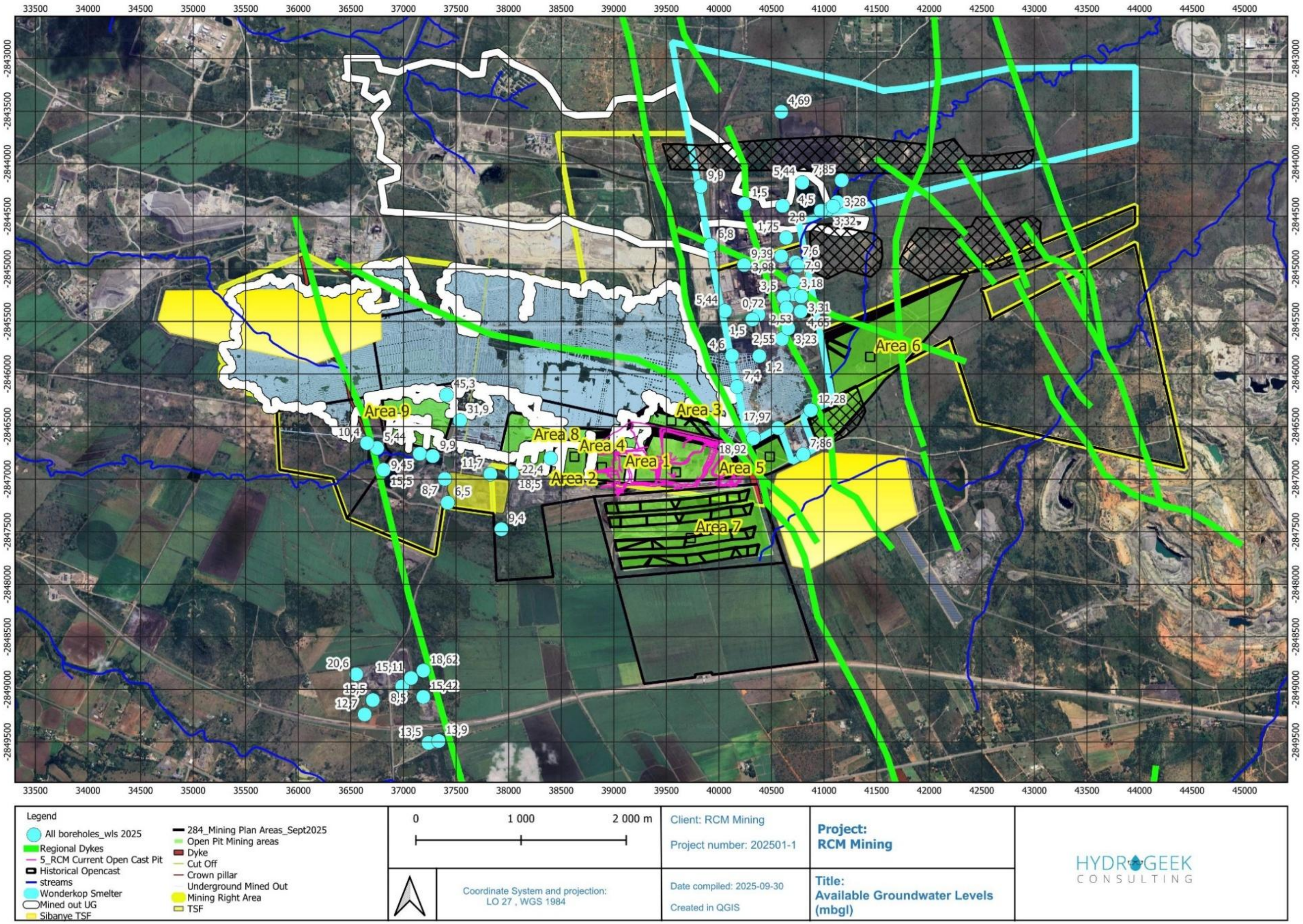

Figure 9 Groundwater depth from hydrocensus (mbgl)

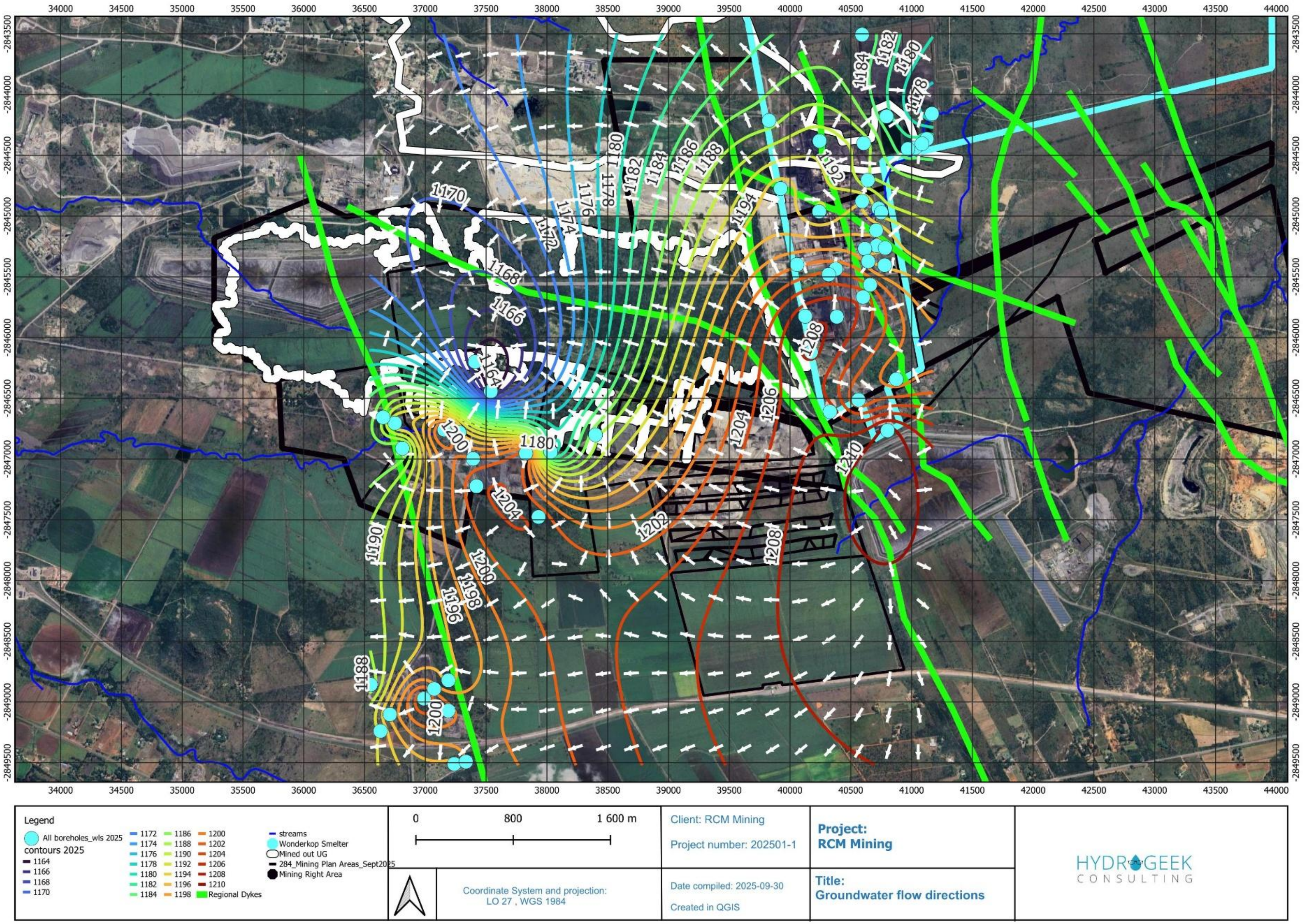

Figure 10 Groundwater flow contours

5.6. Passive inflows

Dewatering requirements for the Area 3 opencast expansion are expected to remain low to moderate. Groundwater inflows into the existing open pit are currently minimal, with natural accumulation in the pit sump averaging approximately 60 m³/day. During periods of active pumping in 2025, abstraction volumes ranged between 200 and 500 m³/day for the current area 1, reflecting relatively limited groundwater ingress under current conditions.

Previous groundwater assessments, however, estimated potential inflows in the order of 1,000–1,700 m³/day, suggesting that inflow rates may increase as mining progresses into deeper, more fractured, or water-bearing geological zones.

For Area 3, which exhibits similar hydrogeological characteristics, low initial inflows are anticipated, but localized increases may occur where dolerite- or fracture-controlled flow paths are intersected. Continuous monitoring of sump accumulation and pumping rates will therefore be essential to validate inflow predictions and optimise dewatering system design during pit advancement.

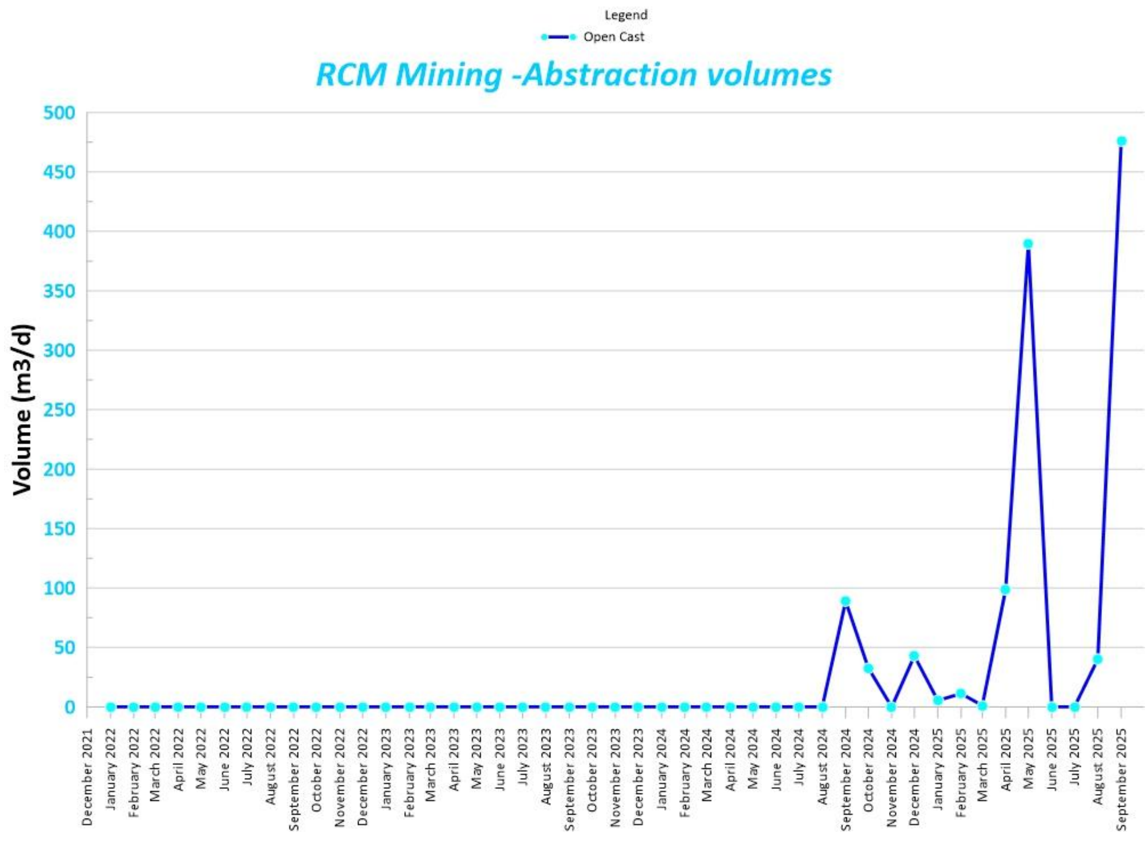

Figure 11 Current measured opencast dewatering from sumps

5.7. Recharge

Groundwater recharge is the process by which water moves downward from the surface to underground aquifers. It occurs through natural processes like precipitation, infiltration, and percolation, as well as through artificial recharge methods.

Pre mining conditions the Hex River would have acted as the regional drain to remove groundwater as baseflow to the river. A small portion of rainfall (approximately 1-3%) would have recharged groundwater. As mining activities started the disturbed areas have been altered. Recharge rates are expected to the higher up to 50% on waste areas and open-cast mining.

5.8. Water Quality Baseline

Quarterly Groundwater samples collected across the Wonderkop area (April 2025) were assessed against the SANS 241:2015 Drinking Water Standards. The dataset provides a representative baseline for both Area 6 and the adjacent new mining areas.

- pH values are generally within acceptable limits (7.1–8.3), indicating neutral to slightly alkaline conditions.
- Electrical Conductivity (EC) and Total Dissolved Solids (TDS) show significant variability, with EC ranging from ~43 mS/m to >2,000 mS/m and TDS ranging between ~260 mg/l and >4,000 mg/l. This reflects heterogeneous water quality across the aquifer system.
- Major cations (Ca, Mg, Na, K) and anions (Cl^-, SO_4^{2-}, NO_3^-) vary widely, with elevated sulphate (>500 mg/l) and chloride (>300 mg/l) concentrations recorded in several boreholes (e.g., WKG-3, WKG-6, WKG-15, WKG-41, WKG-44, WKG-48). These exceedances point to localized zones of saline or mineralized groundwater, likely linked to geological structures or evaporite influence.
- Nitrate (NO_3^-) concentrations are generally low (<5 mg/l), though elevated values up to 82 mg/l (WKG-44) suggest localized anthropogenic influence or oxidizing conditions enhancing nitrate mobility.
- Trace Elements & Metals
- Iron (Fe) and Manganese (Mn) are sporadically elevated. Mn exceeds the guideline (0.4 mg/l) in boreholes such as WKG-3 (0.66 mg/l), WKG-18 (0.86 mg/l), WKG-49 (1.38 mg/l), and WKG-44 (0.94 mg/l).
- Chromium (Cr) is elevated in isolated boreholes, e.g., WKG-11 (0.42 mg/l) and WKG-44 (3.04 mg/l), exceeding the SANS limit of 0.05 mg/l.
- Fluoride (F) is generally below 1.5 mg/l, with the exception of WKG-38 (1.26 mg/l) and WKG-48 (1.94 mg/l).
- Other metals (Al, Cu, Zn, Pb) mostly remain below detection or acceptable limits, though Pb occasionally approaches the threshold (0.01 mg/l).

Dolerite-associated zones appear to host higher salinity and sulphate, while syenite-hosted zones are more dilute but can exhibit localized exceedances.

Implications for Mining Areas For Area 6 and the new pit areas, this baseline indicates:

- A need for ongoing monitoring of sulphate, chloride, and nitrate due to potential exceedances.
- Trace metal risks (Mn, Cr, Fe) that may affect pit inflows and require consideration in dewatering discharge management.
- Water quality heterogeneity strongly linked to structural features, meaning pit intersecting dolerite dykes may encounter more mineralized inflows compared to syenite zones.

6. Source term

Based on a study by Sebata Environmental; Science, 2018:

SES undertook sampling and analysis form RCM production plant in Rustenburg - to establish the leached and solid sample waste classification of the product and by-product of the plant, in line with current National legislation for Waste classification and waste licensing. Analysis also included heavy metal screening to be incorporated into a total impact analysis of the site.

Given that all TCT values are well below TCT_0 limits and LCT results (including Total Chromium) remain below the LCT_1 threshold, the potential for leachable contaminants to migrate into the groundwater system is low. The waste is classified as Type 3 (non-hazardous) and is therefore considered to pose a negligible risk to groundwater quality.

The elevated pH of the waste may slightly influence metal solubility under certain conditions; however, with appropriate containment and drainage controls, no significant groundwater contamination is anticipated**.** Ongoing monitoring of leachate and groundwater is recommended as a precautionary measure to confirm that site conditions remain stable over time.

Tabel 1 Five waste type categories

Criteria	Waste Type
LC > LC3; or TC > TC2	Type 0
LCT2 < LC ≤ LCT3; or TCT1 < TC ≤ TCT2	Type 1
LCT1 < LC ≤ LCT2; and TC ≤ TCT1	Type 2
LCT0 < LC ≤ LCT1; and TC ≤ TCT1	Type 3
LC ≤ LCT0; and TC ≤ TCT0	Type 4

6.1. Aquifer Classification

The aquifer(s) underlying the subject area were classified in accordance with: A South African Aquifer System Management Classification, December 1995 (Parsons, 1995). The aquifers are classified according to the following definitions:

- **Sole Aquifer System:** An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.
- **Major Aquifer System:** Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (Electrical Conductivity of less than 150 mS/m).

- **Minor Aquifer System:** These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.
- **Non-Aquifer System:** These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Based on geological analysis and hydrocensus data it can be concluded that the aquifer system in the study area can be classified as a **Minor Aquifer System.** Even though these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers. It should also be remembered that this Area is located within a Strategic Water Source Area (SWSA), which elevates the sensitivity of the water resource further.

In order to achieve the Aquifer System Management and Second Variable Classifications, as well as the Groundwater Quality Management Index, a points scoring system as presented in Table 4 and Table 5 was used.

Table 4 Ratings – Aquifer System Management and Second Variable Classifications

Aquifer System Management Classification		
Class	**Points**	**Study area**
Sole Source Aquifer System:	6	
Major Aquifer System:	4	
Minor Aquifer System:	2	2
Non-Aquifer System:	0	
Special Aquifer System:	0 – 6	
Second Variable Classification (Weathering/Fracturing)		
Class	**Points**	**Study area**
High:	3	
Medium:	2	2
Low:	1	

Table 5 Ratings - Groundwater Quality Management (GQM) Classification System

Aquifer System Management Classification		
Class	**Points**	**Study area**
Sole Source Aquifer System:	6	
Major Aquifer System:	4	
Minor Aquifer System:	2	2
Non-Aquifer System:	0	

Special Aquifer System:	0 – 6	
Aquifer Vulnerability Classification		
Class	**Points**	**Study area**
High:	3	
Medium:	2	2
Low:	1	

As part of the aquifer classification, a Groundwater Quality Management (GQM) Index is used to define the level of groundwater protection required. The GQM Index is obtained by multiplying the rating of the aquifer system management and the aquifer vulnerability. The GQM index for the study area is presented in Table 6

The level of groundwater protection based on the Groundwater Quality Management Classification:

GQM Index = Aquifer System Management x Aquifer Vulnerability

= 2 x 2 = 4

Table 6 GQM Index for the Study Area

GQM Index	Level of Protection	Study Area
<1	**Limited**	
1 – 3	Low Level	
3 – 6	Medium Level	4
6 – 10	High Level	
>10	Strictly non-degradation	

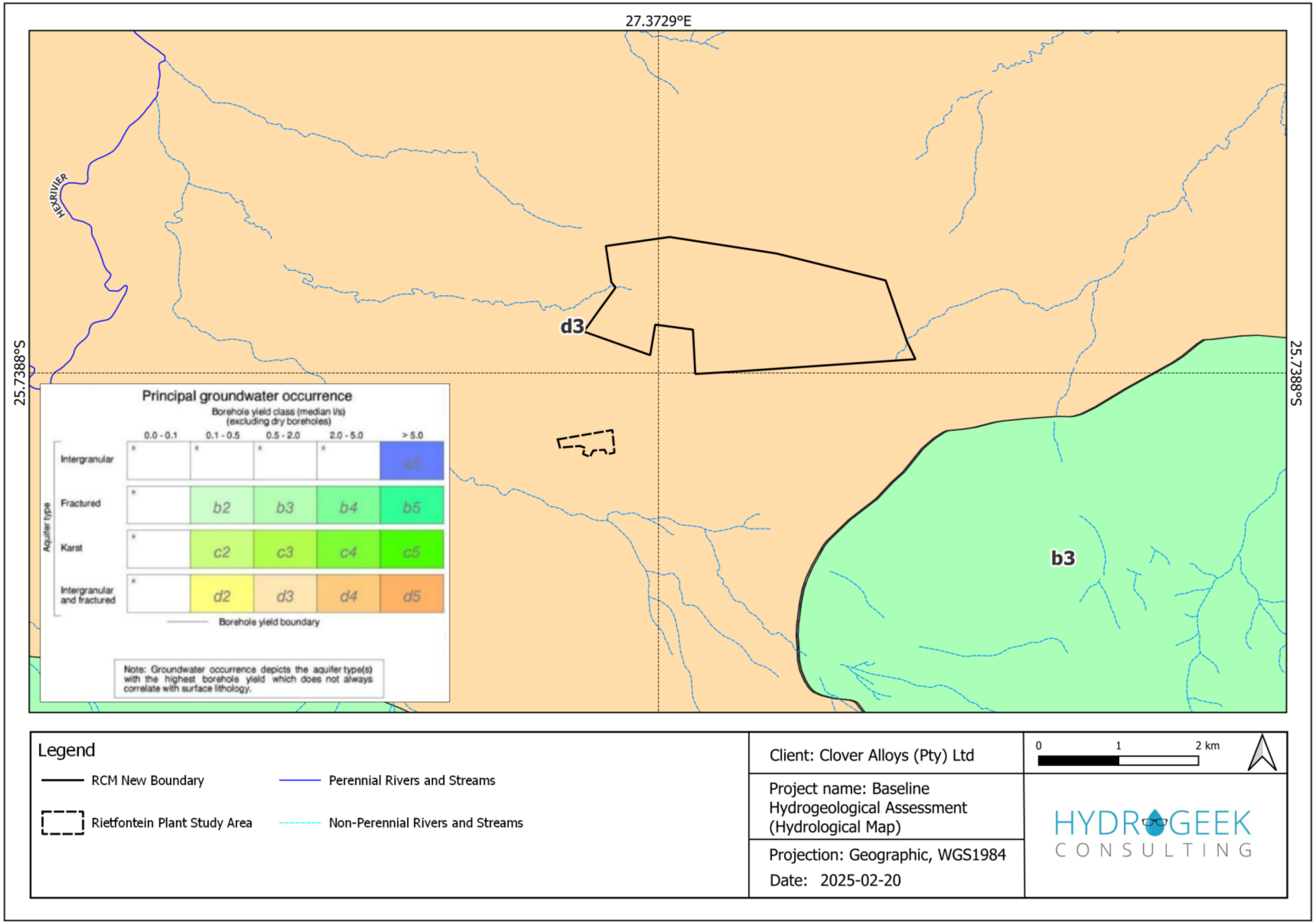

Figure 12 Principal Groundwater Occurrence according to Vegter (1995

6.2. Piper Diagram

A Piper plot is a tri-linear plot where the hydro-chemical composition of water samples is evaluated determining the ratios of predominant cations and anions. The plot is divided into water facies depicting the dominant ratios.

- The calcium-magnesium-bicarbonate (left quarter) of the Piper diagram is normally characterized by recently recharged water.
- The sodium-bicarbonate (bottom quarter) is typical of flow within the aquifer, with the sodium replacing the calcium and magnesium in solution.
- The sodium-chloride dominant (right quarter) is associated with stagnant or slow-moving groundwater with little or no recharge.
- The sulphate dominant (top quarter) is typical of water impacted by the oxidation of pyrite, or other sulphate bearing sources.

The Piper diagram in Figure 13 indicates that we have the groundwater and surface water largely impacted by mining activities. However, we do see a majority of the boreholes plot within the calcium-magnesium-bicarbonate waters possible uncontaminated upstream boreholes. As the groundwater becomes sulphate enriched, we see a migration towards the top quarter.

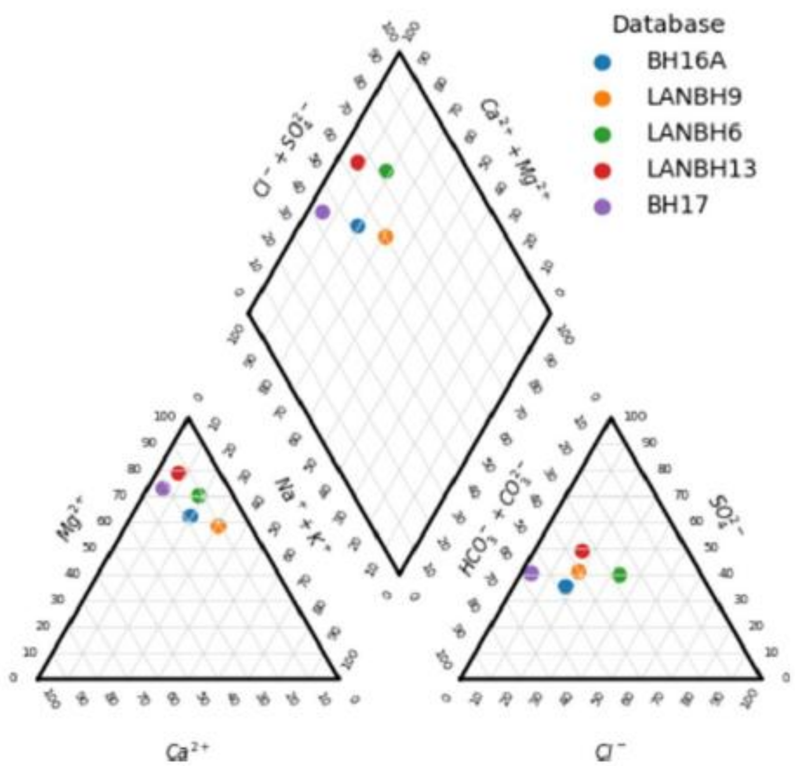

Figure 13 Piper Diagram of Sampled boreholes Feb 2025

7. Conceptual Model of the Aquifer System

The geometrical characterization of hydrostratigraphic units was established through past studies and experience in these geological environments. Subsequently, interpretations were extrapolated to cover an approximate area of 16 x 12 km, utilizing additional data sources such as rock outcrops and surface formation maps.

- The area exhibits varying levels of conductivity and recharge. Hydraulic conductivity ranges from 2.0 x 10-3 m/s for the Shallow weathered to 2.3 x 10-7 m/s for the intact bedrock.
- The hydrogeological framework encompasses opencast pits along with associated underground mine workings. Presently, dewatering operations are ongoing at the underground working and dewatering boreholes. Dewatering is observed in the current opencast mining.
- The hydrostratigraphic units within the region are delineated as follows:

1. Turf Clay
2. Shallow weathered zone
3. Bedrock – Intact

- Groundwater levels are shallow ranging from 5.8 – 48 mbgl. Shallow groundwater levels are unaffected by underground mining. Groundwater discharge takes place through through abstraction boreholes, open pits, underground mining and the Hex River in the west.
- Seepage from Tailings Storage Facility can be seen in elevated groundwater levels around these facilities.

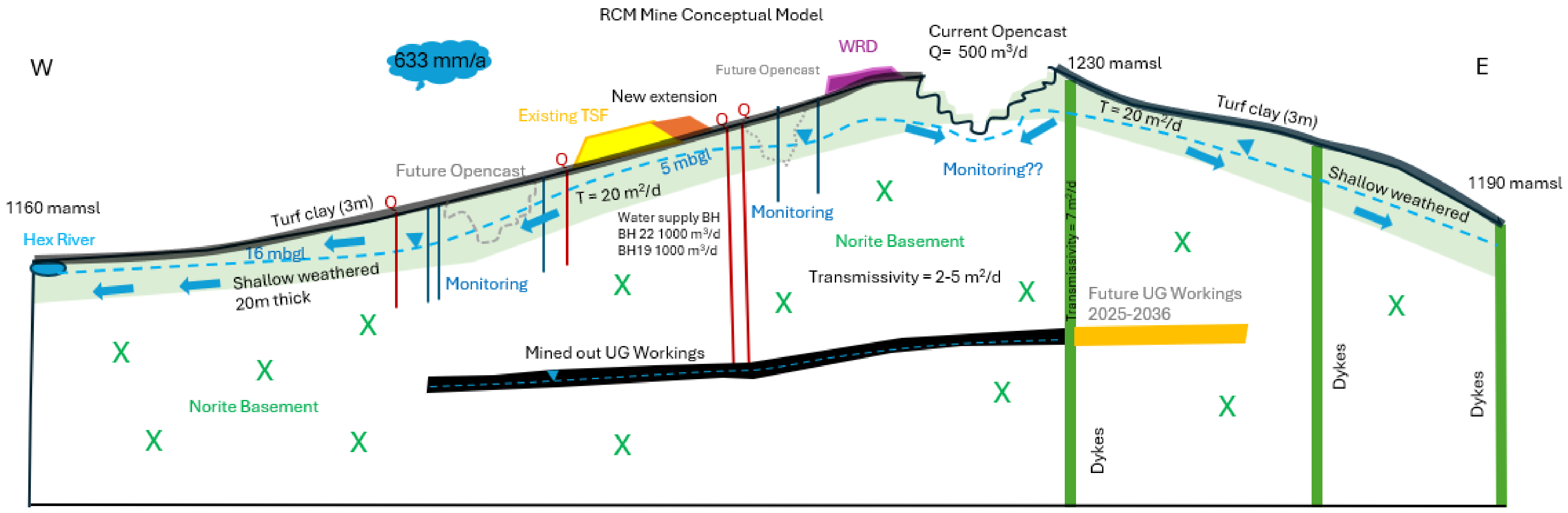

Figure 14 Conceptual model

8. GROUNDWATER FLOW MODEL DEVELOPMENT

8.1. Objectives of the Modelling

- Determination of the future groundwater quality and quantity impacts related to area 3 expansion of existing opencast mining will be modelled.

8.2. Modelling Package

FEFLOW is a powerful 3-D finite element groundwater flow and solute transport model. It can solve transient or steady-state flow, saturated and unsaturated flow, multiple free surfaces or perched water tables.

FEFLOW has a comprehensive selection of graphical tools for building the finite element mesh, assigning property zones and setting boundary conditions. The software includes state-of-the-art 3-D visualization of modelling outputs.

The main advantages of FEFLOW are its versatility in solving different flow and transport problems, flexibility in discretizing problems (representing models with elements) due to use of the finite element method, and flexibility in formulating boundary conditions (due to its use of "constrained" boundaries). This flexibility in model discretization and boundary conditions can be very useful when simulating complex flow problems (e.g. mine developments in structurally controlled bedrock and progressive excavation of open pit and underground mine excavations). FEFLOW is recommended for complex natural resource problems in which complex geometries and/or complex boundary conditions will have to be simulated.

The main disadvantage of FEFLOW is that it requires significant modelling expertise, including in-depth understanding of finite-element methods. The software's flexibility makes it a powerful tool but can also make it difficult to use (for inexperienced users in particular). Setting up FEFLOW may also require more data that may not be readily available.

8.3. Assumptions and limitations

- The geology was based on the 1:250 000 published geological maps as well as 1:50 000 topographical maps.
- QGIS online aerial imagery was used in the layout of the various maps compiled for the current report. The imagery may well be dated and has been used for reference only.
- The model is used for decision making and should be applied accordingly. Modelled impacts may vary at any point and on-going monitoring is required to actively manage the proposed mining activities and possible impacts.
- No site characterization boreholes were drilled for this investigation; aquifer parameters and hydrostratigraphic units were assumed based on historical data and similar studies.
- The investigation utilized data from field surveys and existing monitoring as a snapshot, with further trends to be verified through ongoing monitoring as outlined in the monitoring program.

- The numerical groundwater flow model was developed using site-specific information, excluding influences from neighbouring mining developments.
- The development of the underground mine from Area 3 was not considered in the impact assessment and modelling.

8.4. Model Area

The model domain has been revised to encompass the regional extents of the pits, underground workings and waste areas, ensuring a simplified yet comprehensive representation. The current model domain is considered adequate, with boundary adjustments deemed unnecessary as they would have minimal impact on the modelled outcomes. Notably, topographical highs were predominantly selected in the north and south regions. Additionally, in the western and southeastern areas, a river serves as the outer boundary of the model domain. These adjustments were made to maintain model simplicity while adequately capturing the hydrogeological dynamics of the study area.

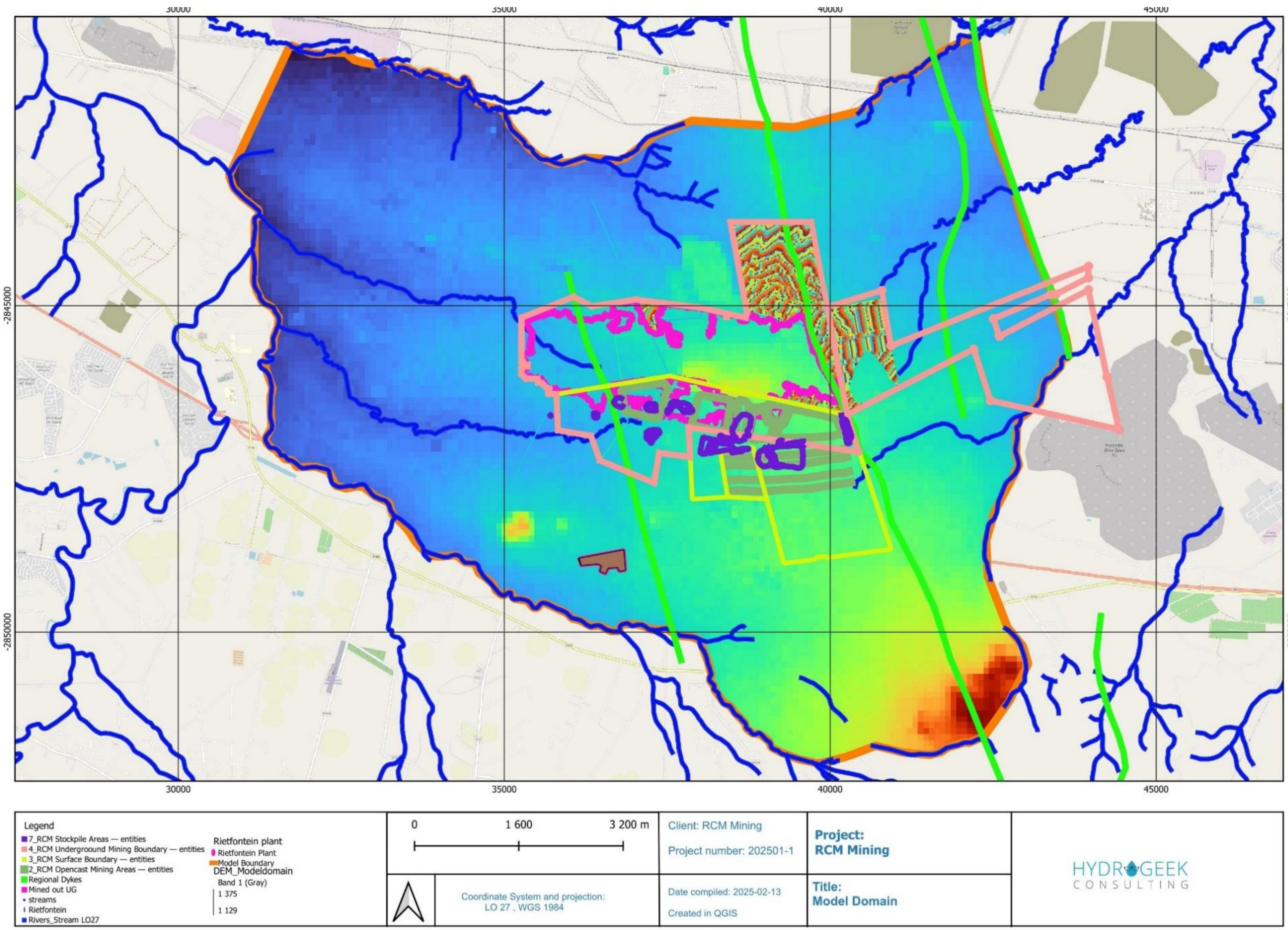

Figure 15 Model boundary

8.5. Construction of the Finite Element Grid

The numerical model encompasses the area of RCM covering a total area of 170 km^2 (approximately 10 km × 17 km). A finite element network (grid) was designed to provide a high resolution of the numerical solution, while at the same time accommodating the large model area. The super element mesh contains the main important features of the conceptual model, e.g. the surface expression of the main hydro lithological aquifer units, structures, drainages and mine facilities. The finite element grid is based on a super element mesh constructed across the area

The finite element grid was compiled using the FEFLOW pre-processing software, which facilitated the construction of six-noded triangular prism elements over the area of investigation. The triangular grid consists of 81.381 elements and 41,050 nodes per slice.

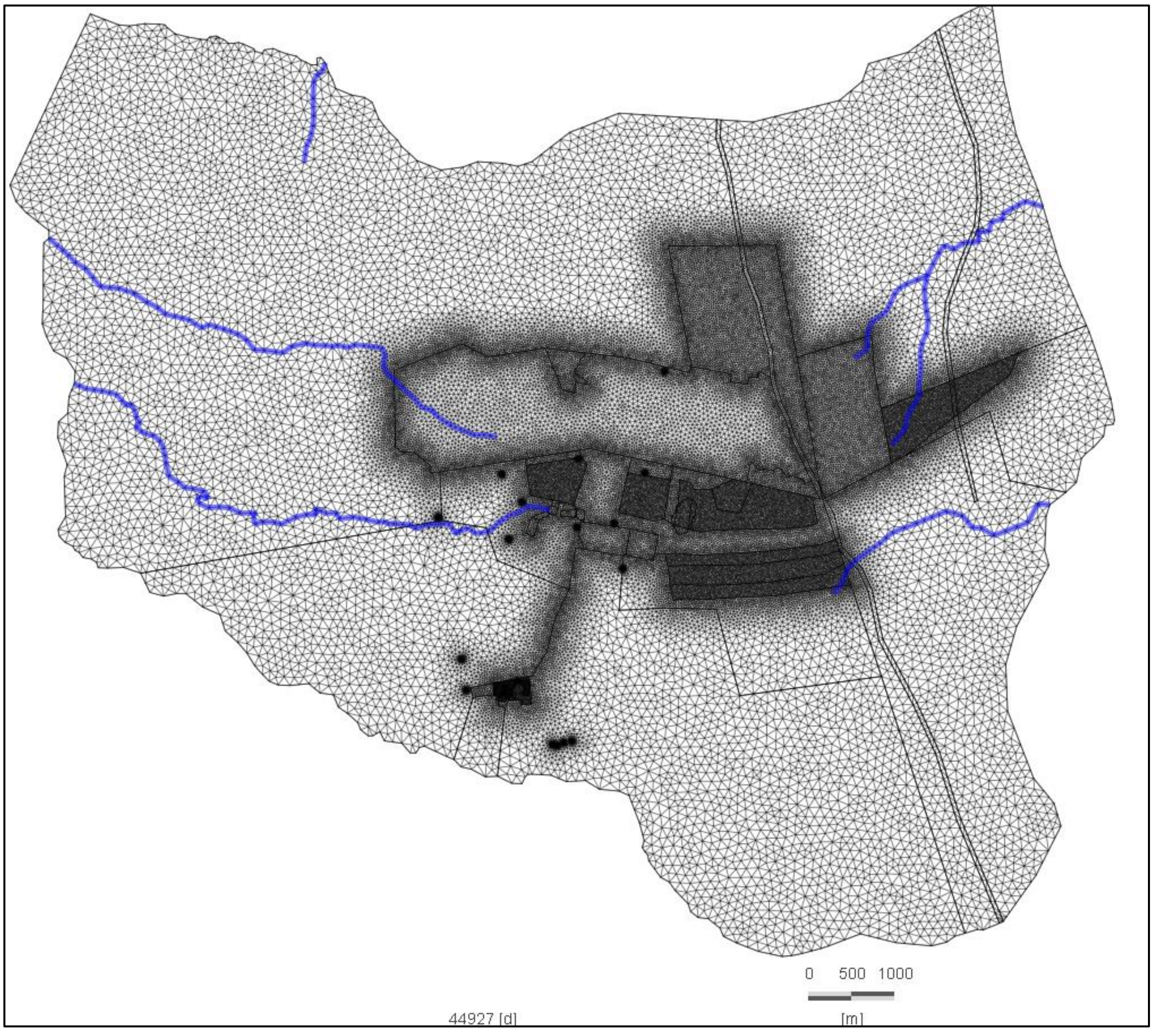

Figure 16 FEFLOW Mesh

8.6. Boundary Conditions

Boundary conditions express the way the considered domain interacts with its environment. In other words, they express the conditions of known water flux, or known variables, such as piezometric head. Different boundary conditions result in different solutions, hence the importance of stating the correct boundary conditions. Boundary conditions in a groundwater flow model can be specified either as:

- Dirichlet Type (or constant head) boundary conditions, or
- Neuman Type (or specified flux, including "no flux") boundary conditions, or
- A mixture of the above

The model area perimeter coincides with topography as no flow boundaries. At the southern boundary a constrained head (max flow 0 m3/d) is specified equal to the water level elevation (water can only leave the model at this position).

Table 7 Boundary Conditions

Boundary	Topographical Feature	Boundary Condition
Northern Boundary	Catchment Divide	Seepage face hydraulic head
Southern Boundary	Surface Water feature	Seepage face hydraulic head
Western Boundary	Surface Water feature	Seepage face hydraulic head
Eastern Boundary	Geological Dyke	No flow boundary Condition

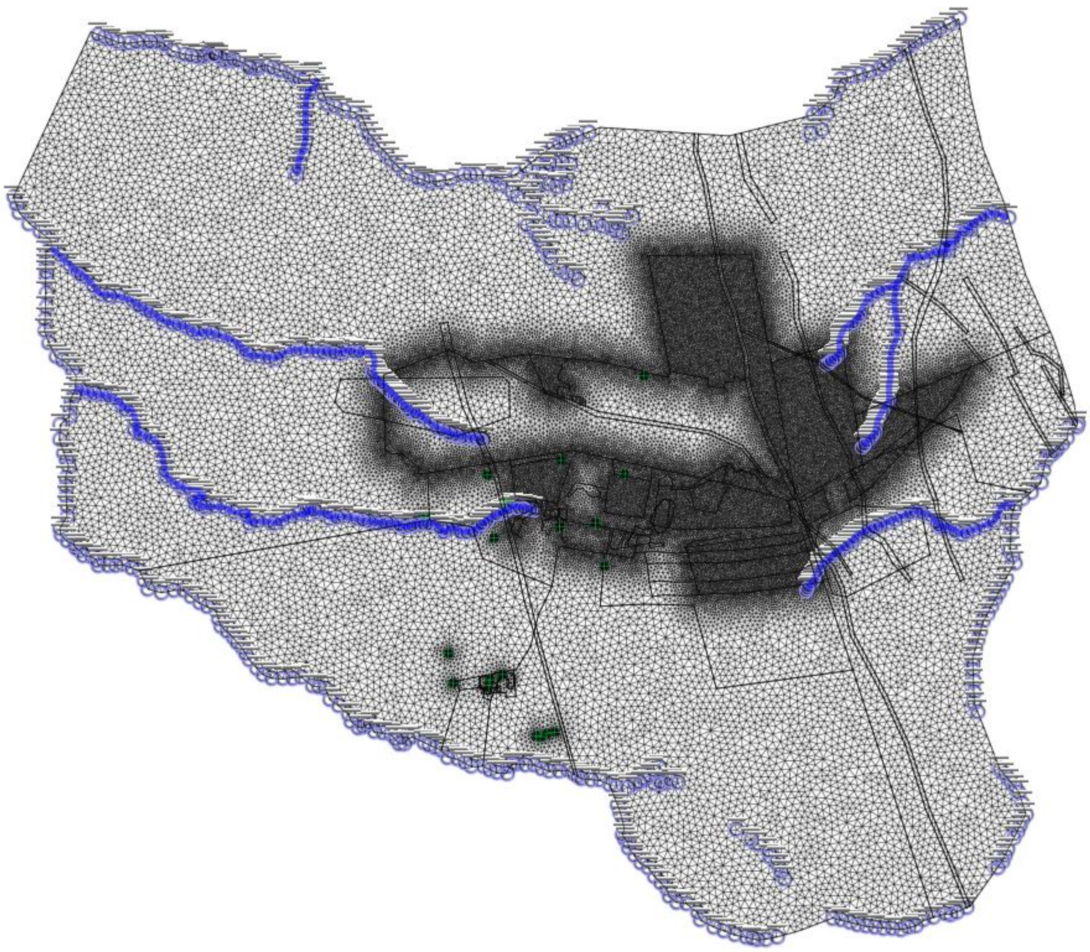

Figure 17 FEFLOW boundary conditions

8.7. Model layers

The hydrostratigraphic units within the region have been discretized into six numerical model layers, providing a structured representation of the subsurface hydrogeological framework:

- Layer 1Turf clay
- Layer 2: Shallow Weathered
- Layer 3: Basement Bedrock

These model layers serve as the foundation for simulating groundwater flow and transport processes within the study area. Additionally, the top slice of the model corresponds to the topography of the area, ensuring accurate representation of surface features and elevations. Conversely, the bottom of the model extends below the surrounding underground mining activities providing comprehensive coverage of the subsurface environment. No mining is currently taking place at the Rietfontein plant. This vertical arrangement enables the integration of both natural and anthropogenic influences on groundwater dynamics, facilitating robust modelling and analysis.

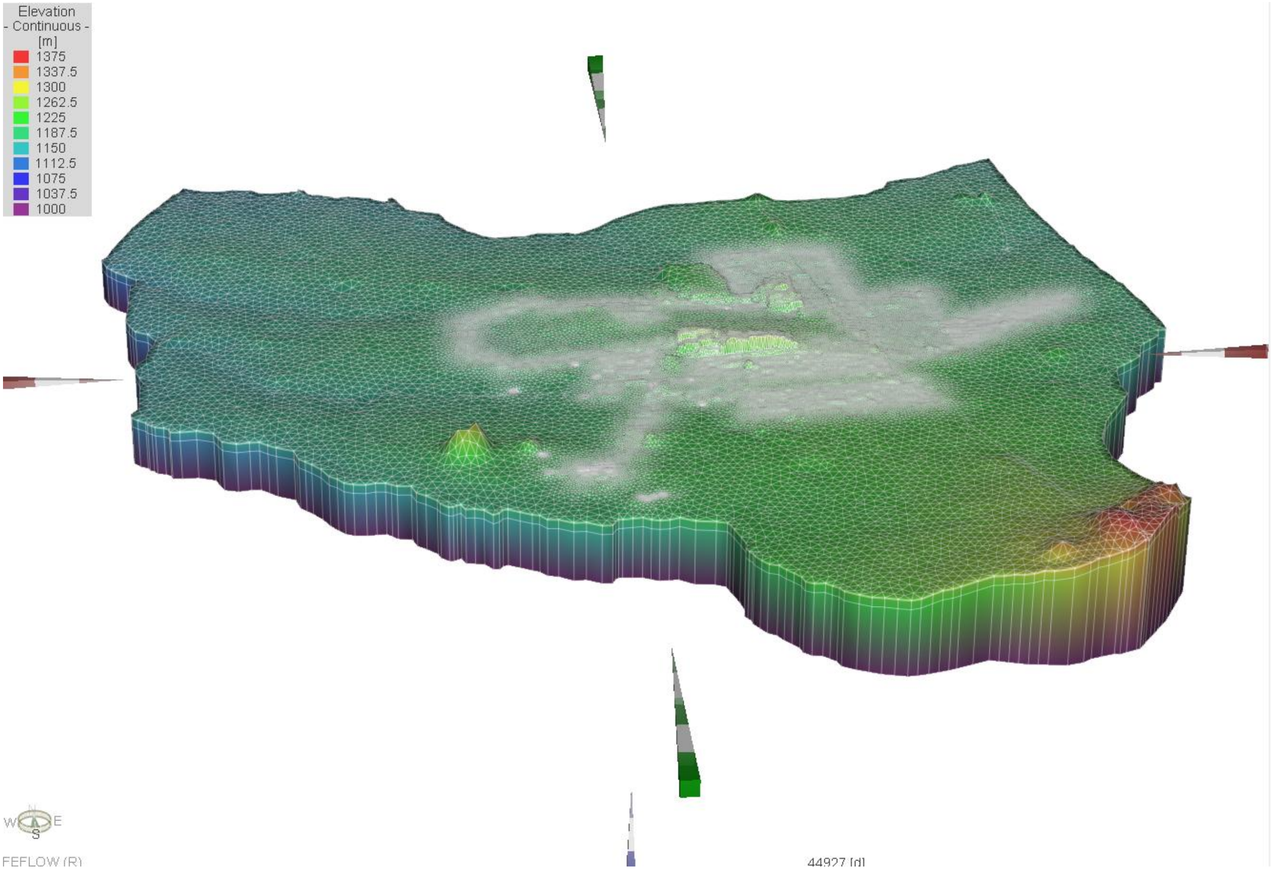

Figure 18 3D Model looking North with elevation

8.8. Aquifer Transmissivity (Hydraulic Conductivity)

The aquifer parameters calibrated in the model is based on the previous aquifer testing in the area. The model calibration refined the parameters as shown in Table 8.

Table 8 Calibrated Aquifer parameters

Hydrostratigraphic Units	Model Layer	Hydraulic Conductivity (m/d)	Anisotropy (Kx/Kz)	Drainage Porosity
Turf Clay	1	3.0×10^{-1}	10	0.15
Shallow Weathered	2	1.0×10^{-1}	10	0.03
Basement bedrock	3	1.0×10^{-5}	10	0.03

8.9. Steady State Simulation (Calibration)

Calibration is the process of identifying a suitable set of hydraulic parameters, boundary conditions, and stresses that best describe the observed hydraulic heads or fluxes within a defined catchment (Anderson and Woessner, 1992). Under steady state conditions the groundwater flow equation is reduced to exclude storativity and only transmissivity (or hydraulic conductivity) and recharge are considered in the calibration process. The model calibration was carried out by adjusting hydraulic conductivity and aquifer recharge.

During steady-state calibration, parameters defining hydraulic properties described in section 2.5.

The following model metrics are used to judge the calibration performance:

- Model convergence
- Water balance error <1%
- RMS error of < 10m
- Normalized RMS of < 10%

Simulated potentiometric surface matches the conceptual understanding of groundwater flow. The steady state results are given in Table 9.

Table 9 Steady state results

Calibration Results			
Groundwater level ID	**Observed Water Level**	**Simulated Water Level**	**Difference**
SC01	1198,1	1196,83034	1,270
SC02	1195,5	1194,5599	0,940
FH01	1196,5	1191,04727	5,453
FH02	1192,3	1190,54156	1,758
RP02	1186,4	1187,94105	-1,541
BH1	1195,38	1198,40846	-3,028
BH2	1200,58	1197,56042	3,020
BH3	1199	1195,04082	3,959
BH4	1198,89	1196,48329	2,407
Mean error (m)	**ME**		**1,582**
Root Mean Square Error	**RMSE**		**2,502**
Normalized Root Mean Square Error	**nRMSE**		**17,65%**

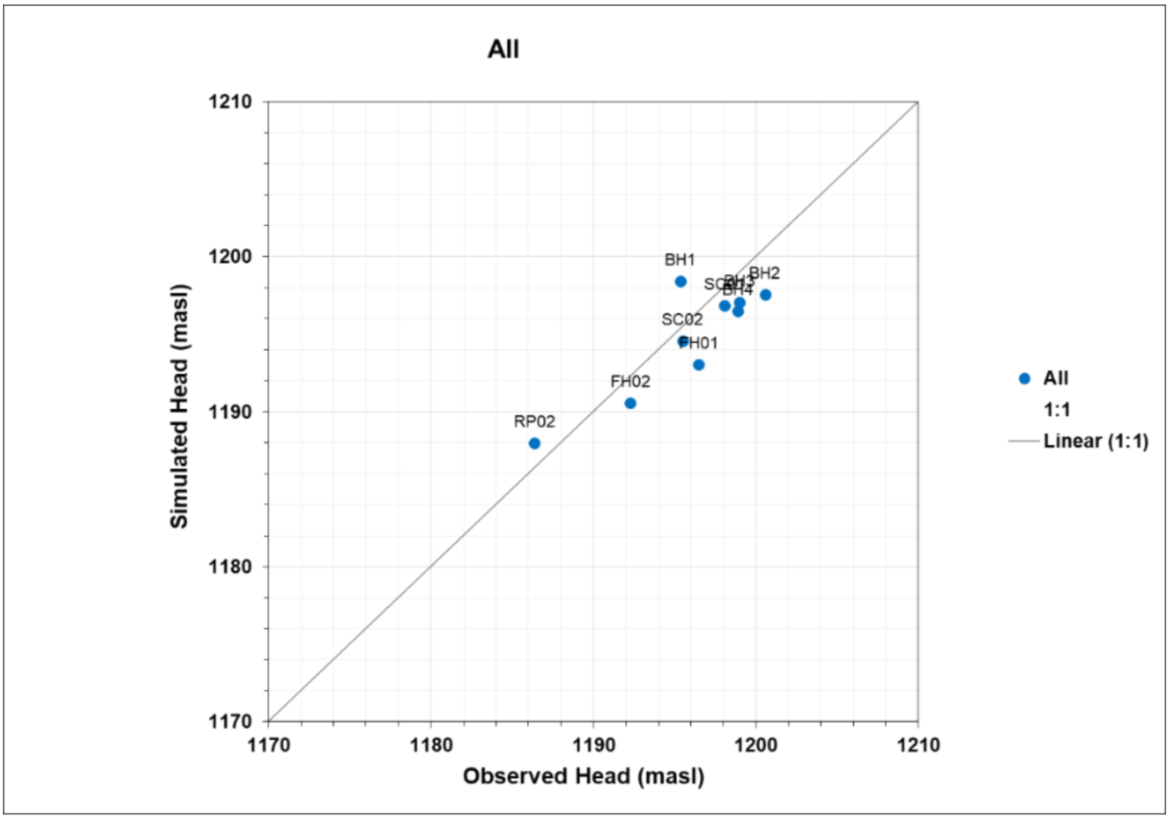

Figure 19 Scatterplot of measured vs simulated heads

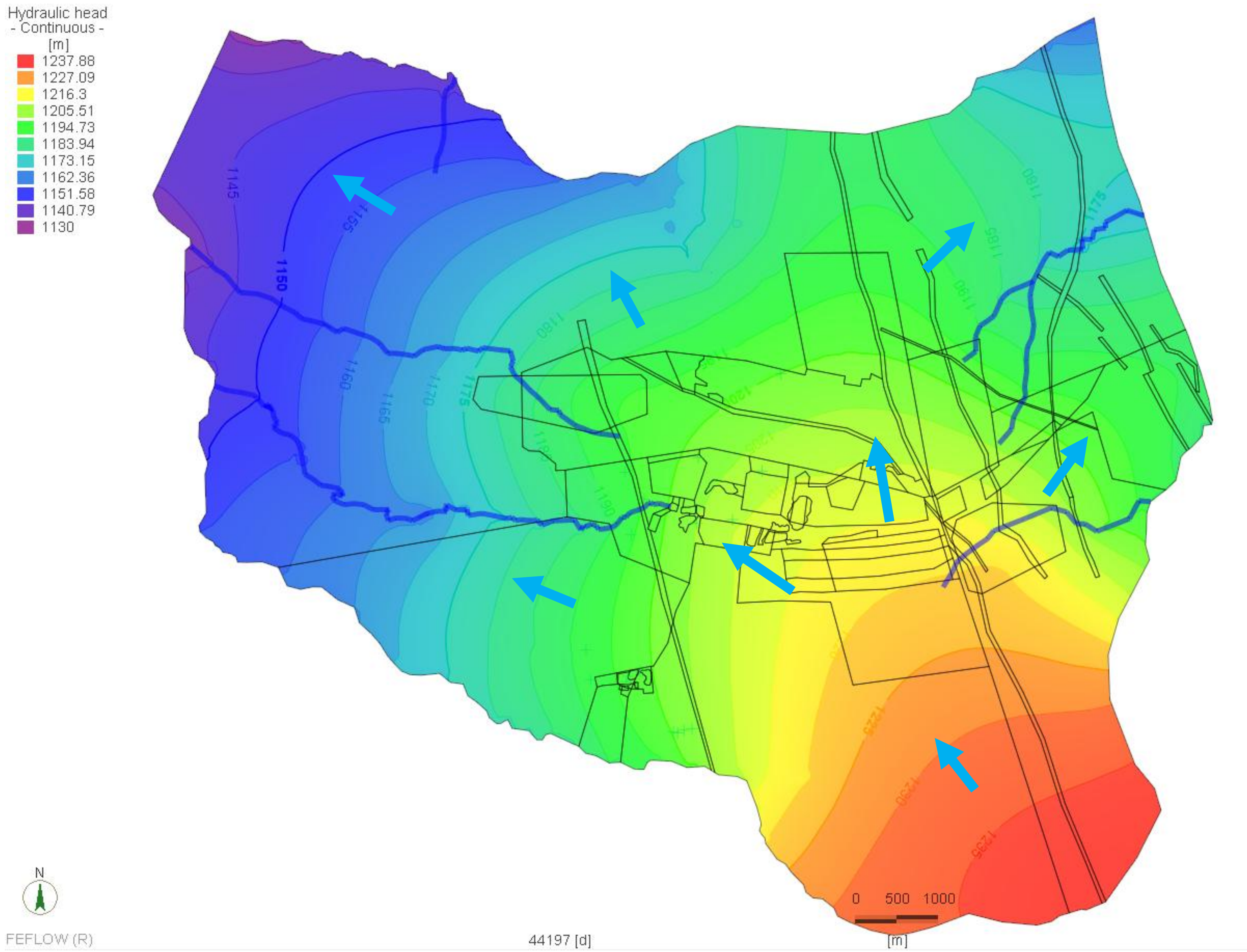

Figure 20 Piezometric surface based on steady state conditions

8.10. Steady State Groundwater Balance

The calibration simulation conducted represents the current groundwater flow conditions as observed in Feb 2025. Figure 21 depicts the interpreted piezometry of the model, representing shallow weathered zone

It can be observed that the abstraction borehole has impacted the groundwater flow. Continuing with the simulations, the model captures the interactions between the abstraction wells and waste facilities impact on groundwater levels. The results provide insights into the flow dynamics and potential changes induced by the plant operations. It's crucial to interpret these findings in conjunction with the calibrated model and acknowledge the limitations and uncertainties inherent in numerical simulations.

Table 10 Water Balance for current conditions

	Inflow (m^3/d)	Outflow (m^3/d)	Balance (m^3/d)
Effective Recharge	2606	0	2606
Water losses from drainages		2427,96	178,04
Water losses from abstraction boreholes		184,54	-6,5
Seepage losses from facilities	6,5		0
Total	**2612,5**	**2612,5**	**0**
Balance error (%)			**0**

8.11. Scenario Modelling

From the calibrated Steady state model, the pits development was simulated to LOM 2038. The scenarios simulated are as follows.

- Scenario 1: Open pits with mine plans simulated to determine groundwater ingress and drawdown effect

8.11.1. 10.11.1 Scenario 1

The scenario was simulated to assess groundwater ingress into the open pit areas, client-provided mining plans with a final pit depth and timeline were incorporated into the model for the open pits. Simulation results indicate that the cumulative effect of all the opencast areas being mined as impacts on each other, reaching 600 m^3/day by 2031.

The simulated drawdown for 2028 and 2031 shows impact of Area 1-4.

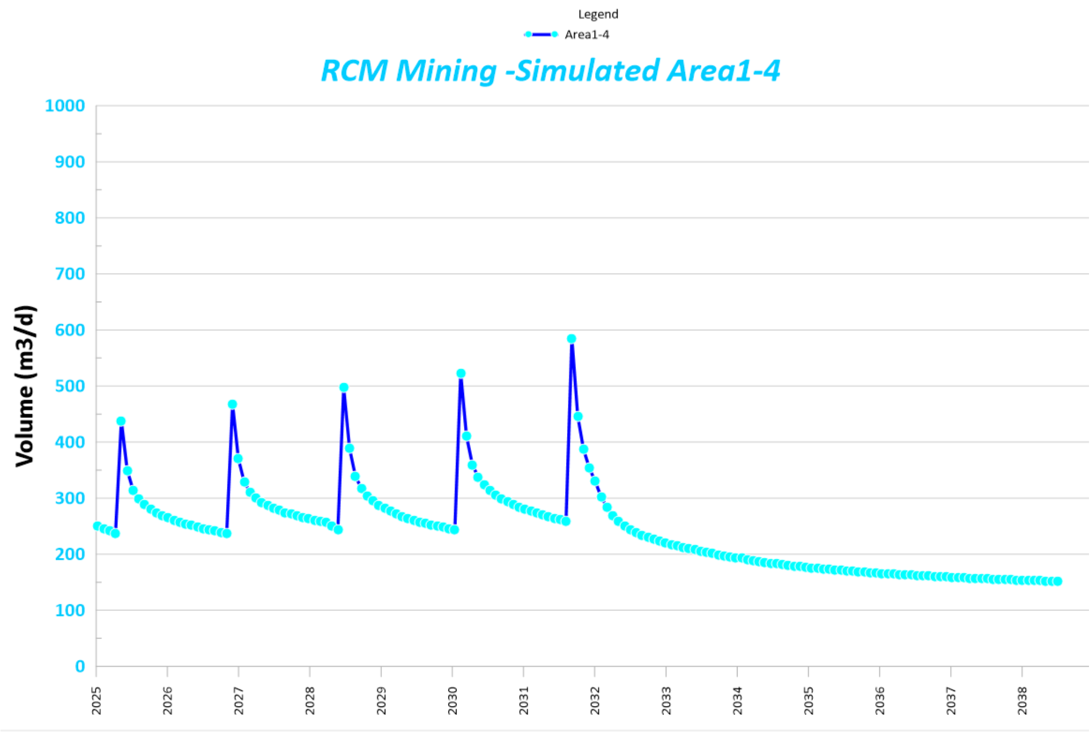

Figure 21 Simulated groundwater ingress for Pit 1-4

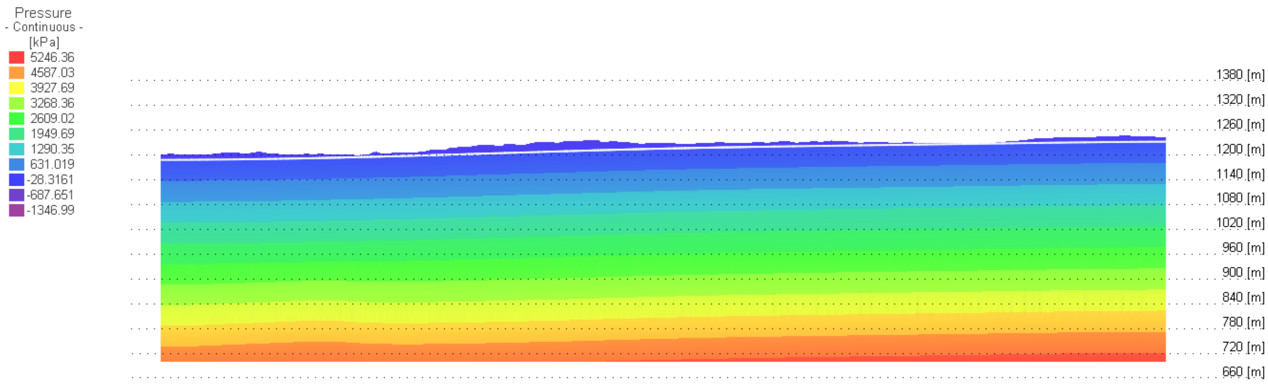

Figure 22 Simulated cross section with zero pressure line in year 2021

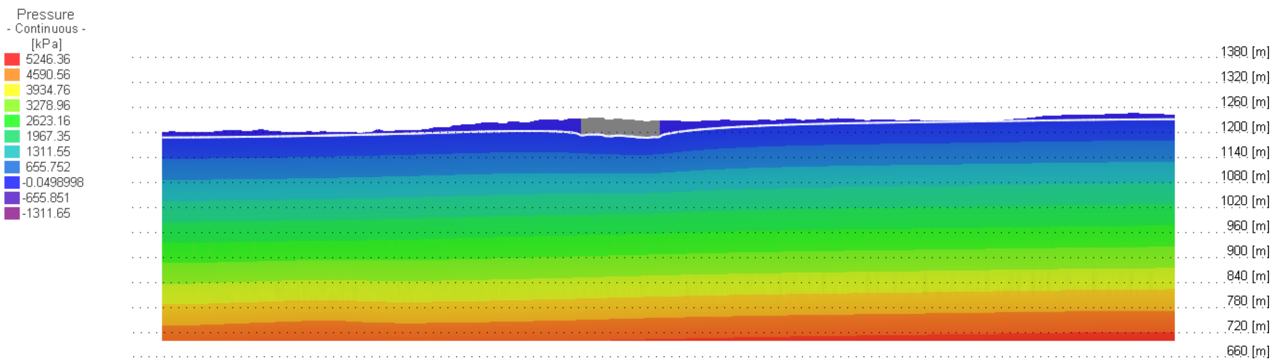

Figure 23 Simulated cross section with zero pressure line in year 2025

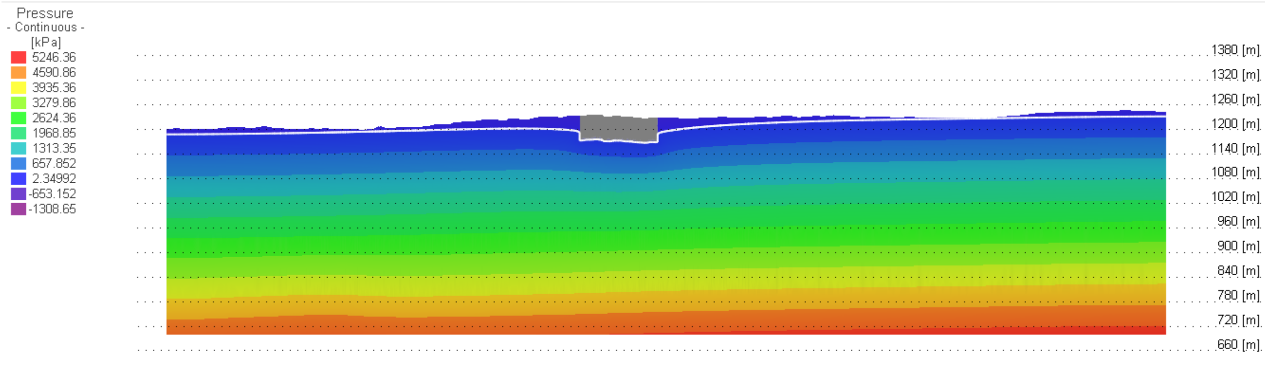

Figure 24 Simulated cross section with zero pressure line in year 2026

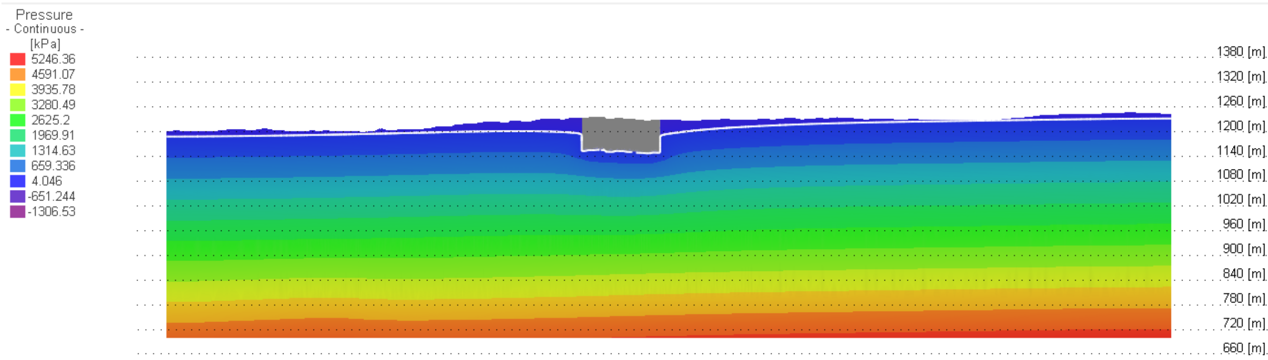

Figure 25 Simulated cross section with zero pressure line in year 2027

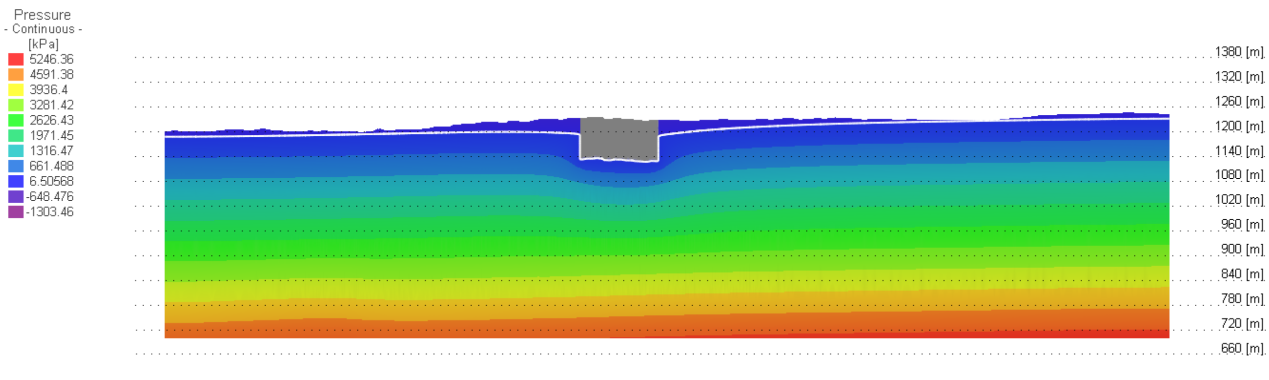

Figure 26 Simulated cross section with zero pressure line in year 2029

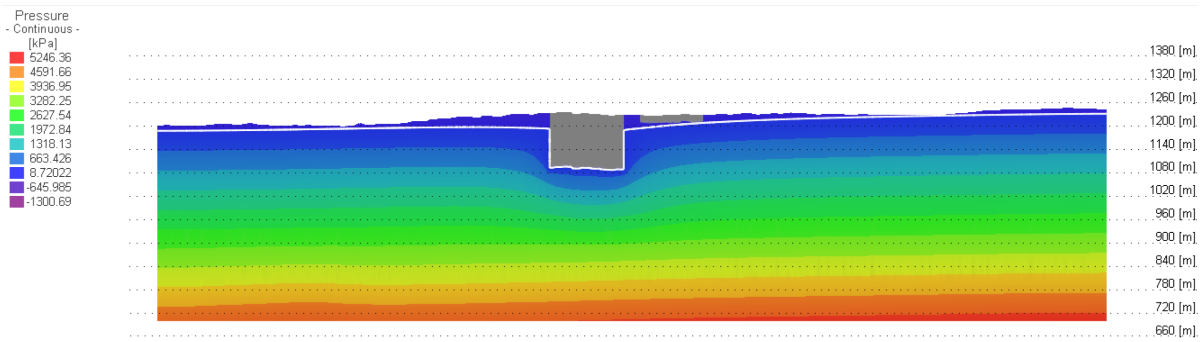

Figure 27 Simulated cross section with zero pressure line in year 2031

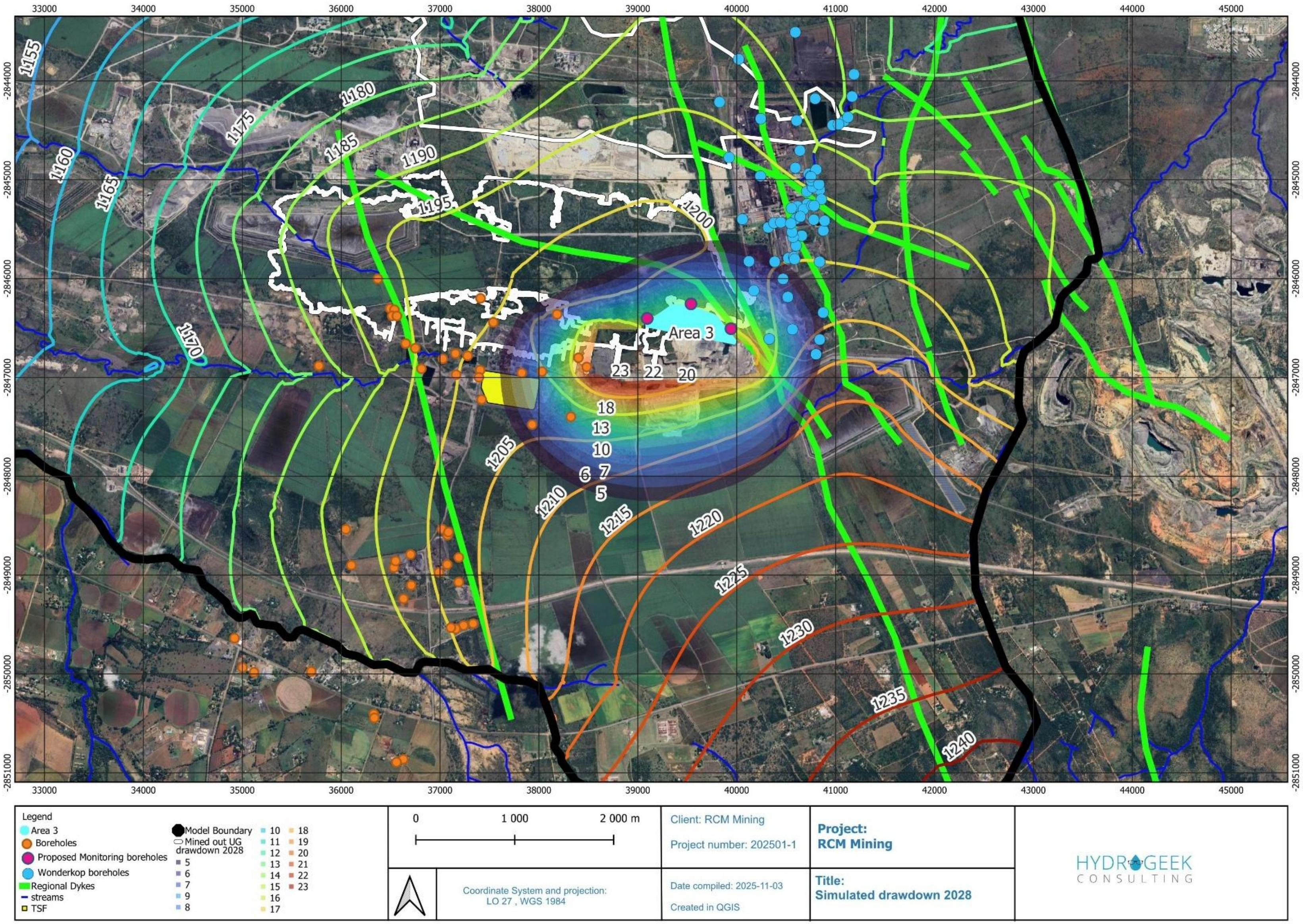

Figure 28 Simulated drawdown in 2028 for Area 1-4

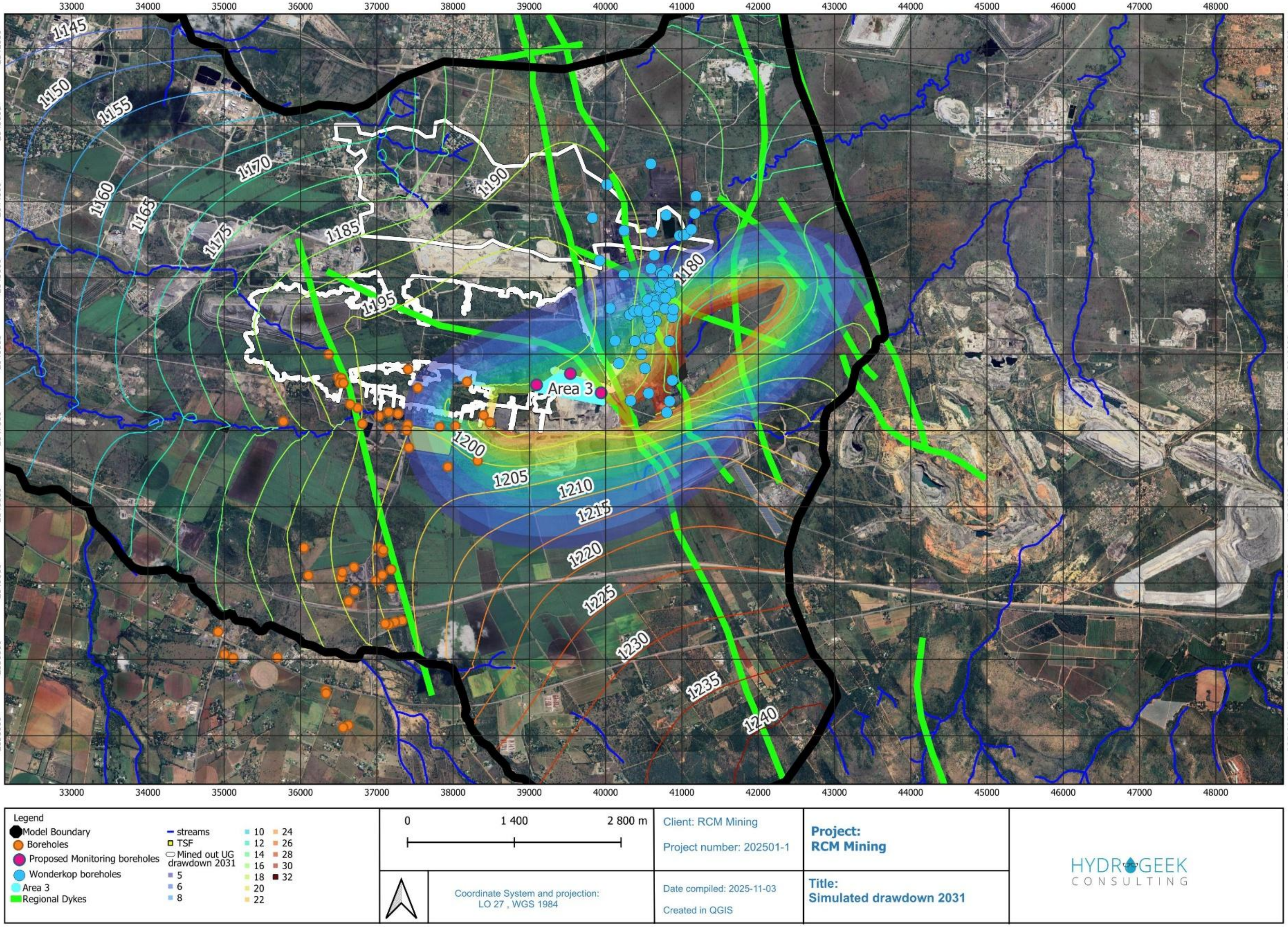

Figure 29 Simulated drawdown in 2031 for Area 1-4

9. HYDROGEOLOGICAL RISK ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PROGRAMME

The aim of this section is to assess the likely hydrogeological impacts that the opencast mining of Area 3 might have on the receiving environment and sensitive receptors. The groundwater risk assessment methodology is based on defining and understanding the three basic components of the risk, i.e. the source of the risk (source term), the pathway along which the risk propagates, and finally the target that experiences the risk (receptor). The risk assessment approach is therefore aimed at describing and defining the relationship between cause and effect. In the absence of any one of the three components, it is possible to conclude that groundwater risk does not exist.

The current impacts from the surrounding infrastructure were assessed to have already impacted the groundwater environment is terms of quality and quantity. The additional Area 3 opencast will not have higher impact on the current groundwater environment; therefore, the current and future impacts can be contained through the proposed mitigations.

9.1. Area 3 Opencast

Statement on Impact Differentiation

The potential environmental impacts associated with the proposed new infrastructure—such as the Area Opencast Area 3 expansion have been reviewed in the context of the existing operations assessed. Based on the nature, location, and function of the planned infrastructure, the associated impacts are anticipated to be materially similar in type, extent, and significance to those already identified and assessed.

9.1.1. Construction and Operational Phase

Impact of Mine Dewatering

According to the calibrated groundwater model, inflows to the expanded pit area (Area 3) are expected to increase to approximately 500 m^3/day. This projected rate is consistent with current inflow volumes measured in Area 1, which is presently under active mining, and therefore considered a realistic estimate. The model further indicates that the 5 m drawdown cone will not extend beyond 1 km from the pit boundary, primarily due to the low permeability of the surrounding noritic lithologies, which significantly limit lateral groundwater movement.

Importantly, the dewatering impact within the newly developed section will be mitigated by prior depressurisation and aquifer storage depletion resulting from ongoing mining in adjacent areas. As a result, the overall impact of additional mine dewatering on the regional aquifer system is assessed to be low in both magnitude and significance. Continued groundwater level monitoring in perimeter boreholes will ensure that drawdown predictions remain within the expected range and that any deviations can be promptly managed through adaptive abstraction control.

Impact of Mine Water Contamination

Groundwater quality that enters the opencast workings will be pumped out as part of the dewatering; therefore, the impact will be minor. The opencast working will remain a sink operationally; therefore, contamination will be contained withing the open cast mine.

9.1.2. Closure and Post Closure

Although limited information exists in order to determine the closure impact of the open cast area, the geohydrologist is of the opinion, in their experience at dealing with similar mining operations in the area, that decant is highly unlikely due to the high evaporation rates (2000 mm/a) that exists and low groundwater ingress areas. The rewatering of these pits usually does not reach decant elevations and acts as a sink for over 100 years.

Importantly, the dewatering impact within the newly developed section will be mitigated by prior depressurisation and aquifer storage depletion resulting from ongoing mining in adjacent areas. As a result, the overall impact of additional mine dewatering on the regional aquifer system is assessed to be low in both magnitude and significance. Continued groundwater level monitoring in perimeter boreholes will ensure that drawdown predictions remain within the expected range and that any deviations can be promptly managed through adaptive abstraction control.

9.2. Mitigation and Management during Construction, Operation, Closure and Post-Closure

Effective mitigation and management of groundwater-related impacts are essential to ensure that mining activities are conducted in a manner that safeguards both surface and subsurface water resources. This chapter outlines the proposed measures to monitor, mitigate, and manage potential groundwater impacts during all phases of the mine life cycle including construction, operation, closure, and post-closure.

The overarching objective of the mitigation plan is to:

- Prevent adverse groundwater drawdown beyond the mine influence area;
- Ensure the protection of aquifers and dependent ecosystems;
- Maintain sustainable water use; and
- Support progressive rehabilitation and long-term environmental stability post-mining.
- Establish a monitoring network through boreholes.

9.2.1. Groundwater Monitoring and Management Framework

Groundwater monitoring needs to continue throughout the life of mine to identify and quantify any adverse impacts on the environment.

- Track the migration of potential groundwater contamination from the mine area;
- Monitor changes in the groundwater level and cone of depression; and
- Assess post-closure recovery of the groundwater system and any residual pollution plume.

The monitoring data will guide the implementation of adaptive management measures to mitigate emerging risks.

9.2.2. Mitigation and Management During the Construction Phase

The construction and operational phase present the highest risk of encountering unexpected groundwater inflows or contaminant migration pathways. The following measures are therefore recommended:

- As part of refining the hydrogeological risk management for Opencast Area 3, I would like to highlight several adaptive mitigation measures that we need to incorporate and check prior to advancing deeper mining and the transition into the underground workings. Just to manage the risk of the mine.
- Area 3 is expected to be the deepest section of the opencast development and will ultimately serve as the access point into the underground. Given this, it is critical that we confirm the current flooded level within the surrounding underground workings before mining progresses into that zone. This will ensure that inflow risks are properly understood, and that the necessary safeguards can be put in place ahead of time.
- In addition, we recommend drilling two dedicated monitoring boreholes one upstream and one downstream of Area 3. These will assist in:
  - Identifying any geological structures or preferential pathways intersecting the pit that could link to other water-bearing zones, whether from adjacent flooded workings or natural aquifers
  - Confirming whether any connected water sources exist that could influence pit stability with underground workings, dewatering demand, or long-term water quality.
  - Providing baseline and ongoing data to manage potential pollution risks associated with both open pit and underground activities.

To finalise these mitigation measures and integrate them properly into the mine’s water management strategy, we will also need updated and more detailed mining plans for both the underground and the open pit phases, particularly around the planned interface points

9.2.3. Mitigation and Management During Operation

During the operational phase, dewatering, abstraction, and wastewater handling activities pose ongoing risks to groundwater levels and quality. The following mitigation measures apply:

- Conduct dewatering activities only near active mining faces to minimise the affected drawdown area.
- Manage abstraction rates within sustainable yield limits of individual boreholes.
- Monitor abstraction volumes to prevent over-exploitation of the aquifer.
- Transfer excess mine water to suitable surface storage or return-water systems, minimising discharge to the environment.
- Reuse treated mine water for dust suppression, haul road spraying, and general operational use.
- Where possible, install an off-take from the reservoir to supply non-potable needs such as dust suppression.
- Prioritise the use of marginal-quality water (mine water or grey water) before using fresh groundwater.
- Continue monthly groundwater quality monitoring, especially down-gradient of the mining area.

- Avoid abstraction from boreholes located close to the mine's pollution sources to reduce contaminant migration.
- Conduct independent annual audits of the monitoring network and water management systems.

9.2.4. Mitigation and Management During Closure and Post-Closure

Limited information exist but the following mitigation could be put in place to mitigate impacts.

Closure planning should begin during active operations, ensuring a smooth transition to post-mining land use with minimal long-term groundwater impacts.

9.2.5. Summary of Mitigation/Monitoring

Groundwater monitoring results should be reviewed quarterly, with management actions adapted accordingly. Where monitoring data indicate emerging risks (e.g., increased inflows, quality deterioration, or plume expansion), corrective measures must be promptly implemented.

Although limited information exists in order to determine the closure impact of the open cast area, the geohydrologist is of the opinion, in their experience at dealing with similar mining operations in the area, that decant is highly unlikely due to the high evaporation rates (2000 mm/a) that exists and low groundwater ingress areas. The rewatering of these pits usually does not reach decant elevations and acts as a sink for over 100 years.

Importantly, the dewatering impact within the newly developed section will be mitigated by prior depressurisation and aquifer storage depletion resulting from ongoing mining in adjacent areas. As a result, the overall impact of additional mine dewatering on the regional aquifer system is assessed to be low in both magnitude and significance. Continued groundwater level monitoring in perimeter boreholes will ensure that drawdown predictions remain within the expected range and that any deviations can be promptly managed through adaptive abstraction control.

The mitigation and management measures outlined in this chapter provide a comprehensive framework to protect groundwater resources during all mine phases. Through rigorous monitoring, responsible abstraction, proactive pollution prevention, and long-term closure management, the project aims to maintain compliance, protect downstream receptors, and ensure sustainable environmental stewardship.

9.3. Risk Assessment Criteria

9.3.1. Procedure

The impact significance rating methodology, as presented herein and utilised for all EIMS Impact Assessment Projects, is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The approach may be altered or substituted on a case by case basis if the specific aspect being assessed requires such- such instances require prior EIMS Project Manager approval. The broad approach to the significance rating methodology is to determine the significance (S) of an environmental risk or impact by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relating this to the probability/ likelihood (P) of the impact occurring. The S is determined for the pre- and post-mitigation scenario. In addition, other factors, including cumulative impacts and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the S to determine the overall final significance rating (FS). The impact assessment will be applied to all identified alternatives.

9.3.2. Determination of Significance

The final significance (FS) of an impact or risk is determined by applying a prioritisation factor (PF) to the post-mitigation environmental significance. The significance is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and Reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$\boldsymbol{C} = \frac{(\boldsymbol{E} + \boldsymbol{D} + \boldsymbol{M} + \boldsymbol{R}) * \boldsymbol{N}}{\boldsymbol{4}}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 11 below.

Table 11 Criteria for Determining Impact Consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)
	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site).
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site).
Duration	1	Immediate (<1 year, quickly reversible)
	2	Short term (1-5 years, less than project lifespan)
	3	Medium term (6-15 years)

	4	Long term (15-65 years, the impact will cease after the operational life span of the project)
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction/ operation/ decommissioning).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected)
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected, or affected environmental components are already degraded)
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; moderate improvement for +ve impacts; or where change affects area of potential conservation or other value, or use of resources).
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease; high improvement for +ve impacts; or where change affects high conservation value areas or species of conservation concern)
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts; or disturbance to pristine areas of critical conservation value or critically endangered species)
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring very high time and cost.
	5	Irreversible Impact.

Once the C has been determined, the significance is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/ scored as per Table 12.

It is noted that both environmental risks as well as environmental impacts should be identified and assessed. Environmental Risk can be regarded as the potential for something harmful to happen to the environment, and in many instances is not regarded as something that is expected to occur during normal operations or events (e.g. unplanned fuel or oil spills at a construction site). Probability and likelihood are key determinants or variables of environmental risk. Environmental Impact can be regarded as the actual effect or change that happens to the environment because of an activity and is typically an effect that is expected from normal operations or events (e.g. vegetation clearance from site development results in loss of species of concern). Typically the probability of an unmitigated environmental impact is regarded as highly likely or certain (management and mitigation measures would ideally aim to reduce this likelihood where possible). In summary, environmental risk is about what could happen, while environmental impact is about what does happen.

Table 12: Probability/ Likelihood Scoring

Probability	1	Improbable (Rare, the event may occur only in exceptional circumstances, the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <5% chance).
	2	Low probability (Unlikely, impact could occur but not realistically expected; >5% and <20% chance).
	3	Medium probability (Possible, the impact may occur; >20% and <50% chance).
	4	High probability (Likely, it is most probable that the impact will occur- > 50 and <90% chance).
	5	Definite (Almost certain, the impact is expected to, or will, occur, >90% chance).

The result is a qualitative representation of relative significance associated with the impact. Significance is therefore calculated as follows:

$$S = C\ x\ P$$

Table 13 Determination of Significance

Consequence	5- Very High	5	10	15	20	25
	4- High	4	8	12	16	20
	3- Medium	3	6	9	12	15
	2- Low	2	4	6	8	10
	1- Very low	1	2	3	4	5
		1- Improbable	2- Low	3- Medium/ Possible	4- High/ Probable	5- Highly likely/ Definite
		Probability				

The outcome of the significance assessment will result in a range of scores, ranging from 1 through to 25. These significance scores are then grouped into respective classes as described in Table 14

Table 14 Significance Scores

S Score	Description
≤4.25	Low (i.e. where this impact is unlikely to be a significant environmental risk/ reward).
>4,25, ≤8.5	Low-Medium (i.e. where the impact could have a significant environmental risk/ reward).
>8.5, ≤13.75	High-Medium (i.e. where the impact could have a significant environmental risk/ reward).
>13.75	High (i.e. where the impact will have a significant environmental risk/ reward).

The impact significance will be determined for each impact without relevant management and mitigation measures (pre-mitigation significance), as well as post implementation of relevant management and mitigation measures (post-mitigation significance). This allows for a prediction in the degree to which the impact can be managed/mitigated.

9.3.3. Impact Prioritization

Further to the assessment criteria presented in the section above, it is necessary to consider each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impacts' post-mitigation significance (post-mitigation). This prioritisation factor does not aim to detract from the significance ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the post-mitigation significance based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 15: Criteria for Determining Prioritisation

Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/ definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable Loss of Resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 15. The impact priority is therefore determined as follows:

$$\boldsymbol{Priority = CI + LR}$$

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from 1 to 1.5 (Refer to Table 16).

Table 16: Determination of Prioritisation Factor

Priority	Prioritisation Factor
2	1

Priority	Prioritisation Factor
3	1.125
4	1.25
5	1.375
6	1.5

In order to determine the final impact significance (FS), the PF is multiplied by the post-mitigation significance scoring. The ultimate aim of the PF is an attempt to increase the post mitigation environmental risk rating by a factor of 0.5, if all the priority attributes are high (i.e. if an impact comes out with a high medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a higher significance).

Table 17: Final Environmental Significance Rating

Significance Rating	Description
<-25	Very High (Impacts in this class are extremely significant and pose a very high environmental risk. In certain instances these may represent a fatal flaw. They are likely to have a major influence on the decision and may be difficult or impossible to mitigate. Offset's may be necessary.
<-13.75 to -25	High negative (These impacts are significant and must be carefully considered in the decision-making process. They have a high environmental risk or impact and require extensive mitigation measures).
-8.5 to -13.75	Medium-High negative (i.e. Impacts in this class are more substantial and could have a significant environmental risk. They may influence the decision to develop in the area and require more robust mitigation measures).
<-4.25 to <-8.5	Medium- Low negative (i.e. These impacts are slightly more significant than low impacts but still do not pose a major environmental risk. They might require some mitigation measures but are generally manageable).
-1 to -4.25	Low negative (i.e. Impacts in this class are minor and unlikely to have a significant environmental risk. They do not influence the decision to develop in the area and are typically easily mitigated.
0	No impact
1 to 4.25	Low positive
>4.25 to <8.5	Medium-Low positive
8.5 to 13.75	Medium-High positive
>13.75	High positive

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.

Table 18 Risk Assessment and final significance

	Pre-Mitigation Scoring									Post Mitigation Scoring									Prioritisation Scores					
Impact	Pre-Nature	Pre-Extent	Pre-Duration	Pre-Magnitude	Pre-Reversibility	Consequence	Pre-Probability	Pre-Mitigation Significance Score	Pre-Mitigation Significance	Post-Nature	Post-Extent	Post-Duration	Post-Magnitude	Post-Reversibility	Post-Consequence	Post-Probability	Post-mitigation Significance Score	Post-Mitigation Significance	Confidence	Cumulative Impact	Irreplaceable loss	Priority Factor	Final score	Final Significance
Impacts on water quantity through passive groundwater ingress	-1	3	3	3	3	-3	3	-9	Medium to high -	-1	1	4	2	3	-2,5	2	-5	Medium to low -	Medium	2	2	1,25	-6,25	Medium to low -
Impacts on water quantity through passive groundwater ingress	-1	3	3	3	3	-3	3	-9	Medium to high -	-1	1	4	2	3	-2,5	2	-5	Medium to low -	Medium	2	2	1,25	-6,25	Medium to low -
Impacts on water quality captured by pit	-1	3	3	3	3	-3	3	-9	Medium to high -	-1	1	3	2	3	-2,25	2	-4,5	Medium to low -	Medium	2	2	1,25	-5,63	Medium to low -
Impacts on water quality captured by pit	-1	3	3	3	3	-3	3	-9	Medium to high -	-1	1	3	2	3	-2,25	2	-4,5	Medium to low -	Medium	2	2	1,25	-5,63	Medium to low -

9.4. Environmental Management Programme Recommendations

The following recommendation for inclusion in the Environmental Management Programme (EMPr) is provided in Table 19 below.

Table 19 EMPr Inclusion

Mitigation Measures	Phase	Timeframe	Responsible Party for Implementation	Monitoring Party (Frequency)	Target	Performance Indicators (Monitoring Tool)
Pre-construction/operation: The current flooded level within the surrounding underground workings must be confirmed prior to mining progresses into that zone. This will ensure that inflow risks are properly understood, and that the necessary safeguards can be put in place ahead of time. In addition, the drilling of two dedicated monitoring boreholes one upstream and one downstream of Area 3 prior to commencing with the expansion is recommended. To finalize these mitigation measures and integrate them properly into the mine's water management strategy, the geohydrologist also requires updated and more detailed mining plans for both Area 3 and the future long term planned underground and the open pit phases, particularly around the planned interface points.	Construction Operation	Prior to construction and ongoing throughout lifespan of mine	Applicant	Monthly water levels and quarterly groundwater quality samples	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores

Mitigation Measures	Phase	Timeframe	Responsible Party for Implementation	Monitoring Party (Frequency)	Target	Performance Indicators (Monitoring Tool)
Monitoring of boreholes drilled -water levels and water quality to be recorded to make sure the impact is monitored and managed.	Construction Operation	Prior to construction and ongoing throughout lifespan of mine	Applicant	Monthly water levels and quarterly groundwater quality samples	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores
24-hour aquifer testing of boreholes to determine the aquifer parameters for the aquifer for the model to be updated	Construction Operation	Prior to construction and ongoing throughout lifespan of mine	Applicant	One off	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores

Mitigation Measures	Phase	Timeframe	Responsible Party for Implementation	Monitoring Party (Frequency)	Target	Performance Indicators (Monitoring Tool)
Monitoring of abstraction volumes of pit and monitoring boreholes water levels to ensure abstraction rates are sustainable and managed.	Construction Operation	Prior to construction and ongoing throughout lifespan of mine	Applicant	Daily measurement of abstractions rates through flow meter on sumps	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores
Stormwater management will be in place to mitigate the risk to groundwater and run off from rainwater into pit.	Construction Operation	Prior to construction and ongoing throughout lifespan of mine	Applicant	One off	Ensure compliance with relevant legislation	

10. Monitoring Plan

Groundwater monitoring boreholes must be evaluated for various chemical constituents, including:

- **Physical and Aesthetic Factors**: pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), and Total Hardness.
- **Macro Elements**: Total Alkalinity (MAlk), Sulphate (SO_4), Nitrate (NO_3), Chloride (Cl), Fluoride (F), Calcium (Ca), Magnesium (Mg), Potassium (K), and Sodium (Na).
- **Micro Elements**: Aluminium (Al), Iron (Fe), Manganese (Mn), Cadmium (Cd), Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb), Cobalt (Co), and Zinc (Zn).
- **Water level**

It is proposed to drill 2/3 boreholes based on geophysical survey; the idea of three boreholes is to have an upstream, downstream and possible a borehole drilled into the underground workings to determine if flooded and possible water level within the workings. Only two of these boreholes would serve as monitoring boreholes.

Table 20 Proposed monitoring network

Borehole	Area monitored	Use
MONBH1	Current opencast and Area 3	Monitoring borehole
MONBH2	Current opencast and Area 3	Monitoring borehole
MONBH3	Current opencast and Area 3	Monitoring borehole

Additionally, calibrated mechanical or electronic flow meters should be installed at all abstraction points to accurately measure and record water abstraction volumes. These figures must be included in the monitoring reports and utilized for updates to the groundwater flow model.

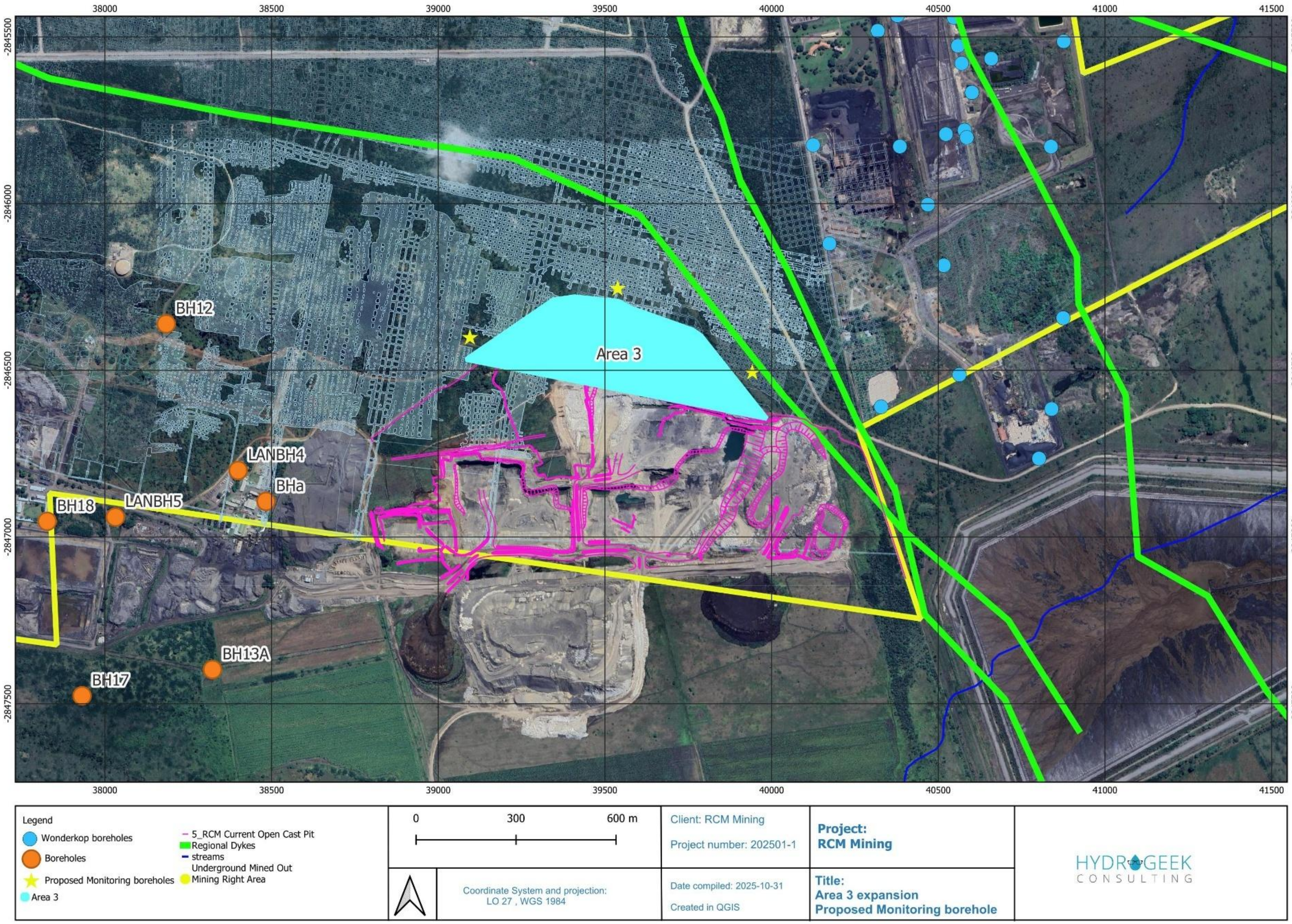

Figure 30 Proposed groundwater monitoring plan

11. CONCLUSION

11.1. Specialist opinion:

The potential environmental impacts associated with the proposed new expansion—such as the Area 3 have been reviewed in the context of the existing operations currently being assessed. Based on the nature, location, and function of the planned infrastructure, the associated impacts are anticipated to be materially similar in type, extent, and significance to those already identified and assessed. However, since limited information exists in determining the impact for the closure and post-closure phases and the impact from underground mining, various recommendations for determining, mitigating, managing and monitoring of the impacts and risks are provided below. The project is considered viable from a groundwater perspective, provided that the recommended mitigation measures and supporting studies are implemented to better define water availability, aquifer parameters and quality on site. The associated risks can be effectively managed through the existing approved and new recommended measures below.

Area 3 is expected to be the deepest section of the opencast development and will ultimately serve as the access point into the underground. Given this, it is critical that the current flooded level within the surrounding underground workings is confirmed prior to mining progresses into that zone. This will ensure that inflow risks are properly understood, and that the necessary safeguards can be put in place ahead of time.

In addition, the drilling of two dedicated monitoring boreholes one upstream and one downstream of Area 3 prior to commencing with the expansion is recommended. These will assist in:

- Identifying any geological structures or preferential pathways intersecting the pit that could link to other water-bearing zones, whether from adjacent flooded workings or natural aquifers
- Confirming whether any connected water sources exist that could influence pit stability with underground workings, dewatering demand, or long-term water quality.
- Providing baseline and ongoing data to manage potential pollution risks associated with both open pit and underground activities.

To finalize these mitigation measures and integrate them properly into the mine's water management strategy, the geohydrologist also requires updated and more detailed mining plans for both Area 3 and the future long term planned underground and the open pit phases, particularly around the planned interface points.

Sincerely,

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HYDROGEEK CONSULTING