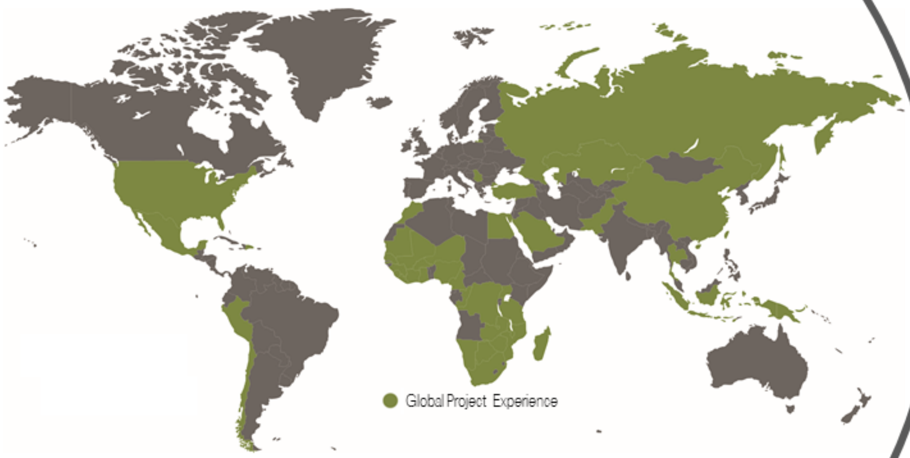

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Proposed Environmental Regulatory Process for the Middeldrift Resources Within the Existing New Clydesdale Colliery Mining Right, Situated in the Magisterial District of Nkangala, Mpumalanga Province

Groundwater Impact Assessment

Prepared for:
Universal Coal Development IV

Project Number:
UCD6587

June 2021

This document has been prepared by Digby Wells Environmental.

Report Type:	Groundwater Impact Assessment
Project Title:	Proposed Environmental Regulatory Process for the Middeldrift Resources Within the Existing New Clydesdale Colliery Mining Right, Situated in the Magisterial District of Nkangala, Mpumalanga Province
Project Number:	UCD6587

Name	**Responsibility**	**Signature**	**Date**
Arjan van 't Zelfde	Report Writer		June 2021
André van Coller	Technical Report Review		June 2021
Mia Smith	Final Report Review		June 2021

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EXECUTIVE SUMMARY

Digby Wells Environmental (hereinafter Digby Wells) was appointed by Universal Coal Development IV, New Clydesdale Colliery (hereinafter Universal Coal) to undertake an Integrated Environmental Application Process for the inclusion of the Middeldrift resources (Middeldrift) into the existing New Clydesdale Colliery (NCC). This report is the groundwater assessment which contributes to the requirements of the integrated environmental assessment and application process. The intention of the proposed project is to exploit the resources through open pit mining methodologies, with the new activities to be authorised entailing:

- Mining of a pan (wetland);
- Construction of a bridge over the Steenkoolspruit to access Middeldrift;
- Diversion of the provincial road which runs through the Middeldrift area; and
- Construction of a new road (linked to the diversion) (approximately 4 km long).

The following was concluded based on this groundwater impact assessment:

- *General:*
  - The area in which the proposed Middeldrift open pit mining is situated is already significantly impacted by adjacent mining activities to the north, west and south of Middeldrift as well as current open pit mining by Universal Coal of the Roodekop area on the southern side of the Steenkoolspruit;
  - The surrounding underground mining activities have already impacted on background groundwater levels in the direct vicinity of Middeldrift, as these mines are still being dewatered or have not been flooded yet;
  - Groundwater levels surrounding the proposed Middeldrift open pit are therefore reduced and were measured to be between approximately 40 – 50 meters below ground level (mbgl), with the exception of the riparian zone close to the Steenkoolspruit where groundwater levels are close to surface (approximately 5 – 10 mbgl);
  - Groundwater use in the vicinity of the proposed mining area is sparse and the closest groundwater users are approximately 1 200 m away from the proposed open pit;
  - Based on the most recent monitoring and hydrocensus data, background groundwater quality shows that the groundwater in the vicinity of Middeldrift is generally of good quality when compared to the South African Water Quality Guidelines (SAWQG). Some exceedances for sulphate, fluoride, iron and manganese were noted, where sulphate can be linked to the historic and current

mining activities. The pH measured at a nearby spring was measured acidic during the hydrocensus;

- For the purpose of this study, it was assumed that barrier pillars will remain between the existing underground mines and the proposed open pit and no inter-mine flow was taken into account; and
- However, this assumption needs to be verified before mining commences; if connections with neighbouring mining areas will be established, groundwater inflows into the open pit may increase significantly.

- *Impacts:*
  - For the modelling of groundwater impacts, impacts of adjacent mining activities were taken into account. Groundwater levels in the newly drilled boreholes, existing monitoring boreholes and hydrocensus boreholes were used to calibrate the model;
  - For the impact assessment, it has been assumed that the underground mine voids in the vicinity of and neighbouring Middeldrift will remain dewatered during the Middeldrift operational phase. This is an acceptable assumption as underground mines are currently not flooded, the proposed Life of Mine (LoM) for Middeldrift is relatively short and mining at Middeldrift is expected to commence in 2022. However, it has been anticipated that these mining areas are flooded after closure of Middeldrift. This is a worst-case assumption with regards to post-closure contaminant plume movement and decant;
  - Only negligible impacts are expected for the construction phase due to limited site infrastructure and no mine waste facilities;
  - Included were two options for mining: option 1 is a smaller open pit with a LoM of 11 years, option 2 is a larger open pit with a LoM of 14 years;
  - Local groundwater levels are drawn down due to adjacent underground mining, and inflows during the operational phase will be relatively low. It is recommended that mining at Middeldrift takes place as soon as possible to keep to these reduced inflows, and to reduce the risk of inter-mine flow;
  - The impact on groundwater levels and resource during the operational phase is expected to be minor. It is not expected that any groundwater users or springs will be impacted upon. Baseflow in the Steenkoolspruit is expected to be reduced by 34% for option 1 and 41% for option 2, and there will be a cumulative impact on the baseflow by the existing and proposed mining at Roodekop. This baseflow will increase again post-closure to near pre-mining volumes;
  - Contaminant plume movement is considered a moderate impact for the post-closure phase and can be limited to a certain extent by mitigation measures, such as proper rehabilitation and soil cover placements;

- Decant is predicted post-closure, for a worst-case scenario in which the adjacent underground voids will be flooded, allowing the backfilled opencast to flood and decant. However, as this is dependant on other mining activities, risks for decant from the various mining areas should be dealt with on a regional scale; and
- Decant from Middeldrift is considered as a moderately significant impact due to the relatively small scale of the activities. Taking into account mitigation options, such as a decant abstraction borehole, this would reduce decant generation and would lower the significance of this impact to minor.

The impacts above as determined are as expected based the best knowledge of the current site conditions.

However, to improve the accuracy of this study, the following *recommendations* are made in order of importance:

- Delineations of existing mining areas should be confirmed before mining commences to avoid the creation of direct flow paths and significant inter-mine flows between existing underground voids and the proposed Middeldrift open pit;
- Mine plans and schedules for the adjacent underground mines should be obtained to understand when the end of LoM will be for each operation, and when flooding of the voids will take place;
- A numerical flow and contaminant transport model should be developed for region, including historic, current, and planned mining activities. This consolidated model can then be used as a management tool to assess and quantify the regional impacts;
- A feasibility study for a pit lake/final void or constructed decant point is recommended to assess the impact and costs of such mitigation measures. This study should be based on a post-closure landform design. This could reduce the post-closure impacts, as well as the required volume of water to be treated post-closure.
- Kinetic leaching tests and geochemical modelling should be performed on coal and backfill material to obtain trends and variability in leachate and decant quality over time, as only static leach tests were used as input for post-closure seepage quality in this assessment;
- The numerical groundwater model should be updated and re-calibrated every two years to reflect the operational and post-rehabilitation conditions and most recent groundwater levels; it should also be updated as new hydrogeological or geochemical information becomes available, or when there are significant changes made to the mine schedule;
- Decant volumes should be re-calculated every two years using numerical models and spreadsheet calculations, and should be based on the rehabilitation design of the open pit;

- Recharge estimates to the backfilled pit should be updated once when backfilling is complete, based on the actual characteristics of the backfill and capping to improve the accuracy of the decant volumes and time-to-decant;
- A mine water decant action plan should be developed to address the impacts associated with decant, seepage and base flow salt loads for the operational and post-closure impacts;
- A surface water blending model should be conducted to assess the risk associated with the salt load contribution to the base flow;
- The groundwater monitoring network should be updated based on the existing and proposed monitoring positions as per this report; and
- A monitoring database should be established that contains all historic and future groundwater monitoring data.

Provided all the above mentioned recommended measures and studies are implemented, there is no reason why the mining of the proposed project should not proceed from a hydrogeological point of view.

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ACRONYMS AND ABBREVIATIONS

Abbreviation	Description
ABA	Acid Base Accounting
AG	Acid Generating
AMD	Acid Mine Drainage
AP	Acid Potential
ARD	Acid Rock Drainage
BH	Borehole
Coeff. Var.	Coefficient of Variance
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DW test	Reagent (Distilled) Water test
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EM	Electro Magnetic geophysical survey
EMP	Environmental Management Plan
EMPr	Environmental Management Programme report
ESIA	Environmental and Social Impact Assessment
ET	Evapotranspiration

Abbreviation	Description
GIS	Geographical Information System
GMWL	Global Meteoric Water Line
GPS	Global Positioning System
He	Hectares
Hz	Hertz
ICP	Inductively Coupled Plasma
ICP-OES	Inductively Coupled Plasma Atomic Emission Spectroscopy
IPP	Independent Power Producer
IWULA	Integrated Water Use License Application
k	Hydraulic conductivity
kh	Horizontal hydraulic conductivity
kv	Vertical hydraulic conductivity
km	kilometre
ktpm	Kilotons per month
L/h	Litre per hour
L/s	Litre per second
LC	Leachable Concentration
LCT	Leachable Concentration Threshold
LoM	Life of Mine
mamsl	metres above mean sea level
m_3	cubic metre
MAE	Mean Annual Evaporation
Mag	Magnetic geophysical survey
mamsl	Meters above mean sea level
MAP	Mean Annual Precipitation
mbgl	Meters below ground level
mg/ℓ	milligrams per litre
mm	millimetre
mm/a	millimetre per annum
ms	milli-seconds
mS/m	milli Siemens per metre

Abbreviation	Description
Mtpa	Million ton per annum
NAG	Net Acid Generating
NEMA	National Environmental Management Act, 1998
NEMWA	National Environmental Management: Waste Act, 2008
NMD	Neutral Mine Drainage
NNP	Net Neutralising Potential
NP	Neutralising Potential
NPR	Neutralising Potential Ratio
nT	nanoTesla
NTU	Nephelometric Turbidity Units
PEST	Parameter ESTimation
PAG	Potential Acid Generating
PAN	Potential Acid Neutralising
PCD	Pollution Control Dam
RMSE	Root Mean Square Error
ROM	Run Of Mine
S	Storativity
SANAS	South African National Accreditation System
SANS	South African National Standards
SPLP	Synthetic Precipitation Leaching Procedure
SS	Sulphide-Sulphur
St. Dev.	Standard Deviation
Sy	Specific yield
T	Transmissivity
T	Transmissivity
TC	Total Concentration
TCT	Total Concentration Threshold
TDS	Total Dissolved Solids
UTM	Universal Transverse Mercator
WHO	World Health Organisation
WMA	Water Management Area

Abbreviation	Description
WRD	Waste Rock Dump
wt. %	Weight percentage
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence

1 Introduction

Digby Wells Environmental (hereinafter Digby Wells) was appointed by Universal Coal Development IV, New Clydesdale Colliery (hereinafter Universal Coal) to undertake an Integrated Environmental Application Process for the inclusion of the Middeldrift resources (Middeldrift) into the New Clydesdale Colliery (NCC). This report is the groundwater assessment which contributes to the requirements of the integrated environmental assessment and application process.

The study was conducted to comply with the following legislation:

- Section 21 of the National Water Act, 1998 (Act No. 36 of 1998) (NWA);
- National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA);
- Environmental Impact Assessment (EIA) Process in terms of the EIA Regulations, 2014 (GN R982 of 04 December 2014, as amended) (the “EIA Regulations, 2014”);
- National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEM:WA); and
- Section 102 of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA).

2 Project Description

The Project is located in the Kriel district of the Mpumalanga Province. Middeldrift is a greenfields area and lies north of the NCC Diepspruit Mining Area (an underground mining operation) and in the same Mining Rights (MR) area. The Project area and location of the proposed open pit are indicated in Figure 2-1. The intention is to exploit the resources through open pit mining methodologies.

The proposed new activities at Middeldrift will entail:

- Mining of a pan (wetland);
- Construction of a bridge over the Steenkoolspruit to access Middeldrift;
- Diversion of the provincial road which runs through the Middeldrift area; and
- Construction of a new road (linked to the diversion) (approximately 4 km long).

The construction, operation and decommissioning phases of the Project shall comprise of the activities in Table 2-1. The impact of these Project activities on the groundwater environment will be determined in the groundwater impact assessment.

Table 2-1: Project Activities

Phase	Activity
Construction	Removal of vegetation / topsoil for establishment of mining and linear infrastructure
	Construction of access road, haul roads, bridge crossing construction and diversion of the existing provincial road which runs through the area of the Middeldrift site
	Stockpiling of soils and rock dump establishment.
Operational	Maintenance of haul roads, pipelines, machinery, water, effluent and stormwater management infrastructure and dump/stockpile areas.
	Removal of rock(blasting)
Decommissioning	Concurrent rehabilitation as mining progresses
	Removal of infrastructure, soil stockpiles and rock dumps
	Post-closure monitoring and rehabilitation
	Removal of Bridge Crossing
	Closure of the mine

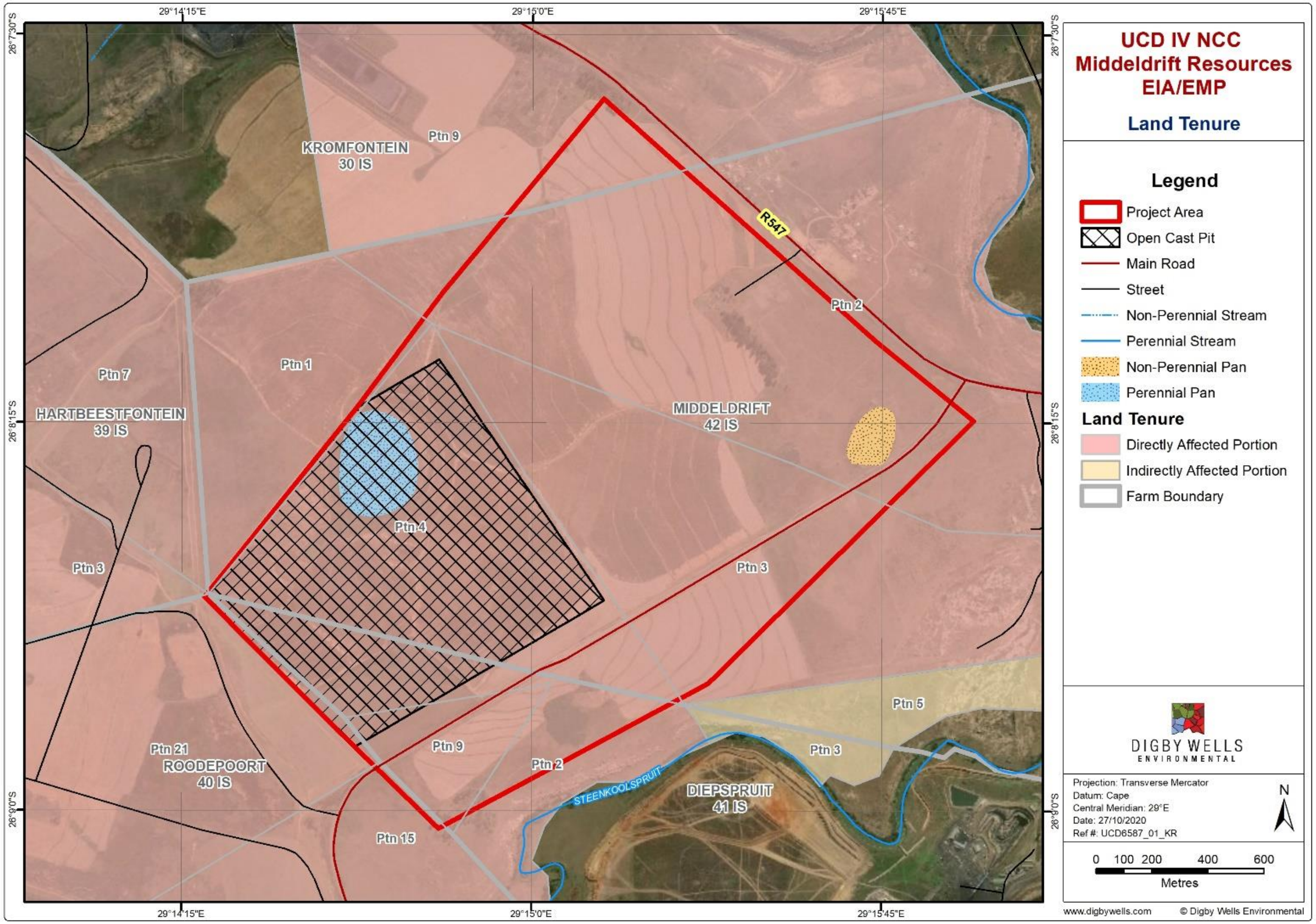


Figure 2-1: Land Tenure Map

3 Legal and Administrative Framework

Applicable legislation, standards and guidelines used in this study are summarised in Table 3-1.

Table 3-1: Applicable Legislation, Regulations, Guidelines and By-Laws

Legislation, Regulation, Guideline or By-Law	Applicability
National Water Act (Act 36 of 1998) NWA makes provision for water resource management, protection of the quality of water resources and recognising the need for the integrated management of all aspects of water resources to achieve sustainable use of water.	Legal requirement on the use of water for mining and related activities aimed at the protection of water resources.
DWS[1] Best Practice Guideline – G1: Storm Water Management Plan (SWMP); and GN R704 of 1999 These are guidelines provided by the Department of Water and Sanitation (DWS) for storm water control which addresses the following principles: • Delineation of clean and dirty areas contributing to runoff (based on the final layout plans) Temporary drainage installations designed, constructed, and maintained for recurrence periods of at least a 50-year, 24-hour event; and • Site-specific assessments to establish the appropriate mitigation measures and surface water monitoring programme.	Pollution prevention and minimisation of impacts on surface water resources to comply with the NWA.
SANS 241: 2015 for Drinking Water and the Resource Water Quality Objectives (RWQOs) for Management Unit 7 of the Witbank Dam Catchment (DWS, 2016) SANS 241-1 consists of standards under the general title *Drinking water*: *Part 1: Microbiological, physical, aesthetic and chemical determinants; and* *Part 2: Application of SANS 241-1*. RWQOs are water quality limits defined by the National Water Act as “clear goals relating to the quality of the relevant water resources.” RWQOs are given as numeric or descriptive in-stream (or aquifer) water quality objectives typically set at a finer resolution (spatial or temporal) to provide greater detail upon which to base the management of water quality.	Mining and related activities for the Project will likely have water quality impacts which should be monitored.

[1] Previously the Department of Water Affairs (DWA)

Legislation, Regulation, Guideline or By-Law	Applicability
<u>National Environmental Management Act, 1998 (Act No. 107 of 1998) and EIA Regulations, 2014 (as amended)</u> NEMA, as amended, was set in place in accordance with Section 24 of the Constitution. Certain environmental principles under NEMA have to be adhered to, to inform decision making for issues affecting the environment. Section 24 (1)(a) and (b) of NEMA state that: *The potential impact on the environment and socio-economic conditions of activities that require authorisation or permission by law and which may significantly affect the environment, must be considered, investigated and assessed prior to their implementation and reported to the organ of state charged by law with authorizing, permitting, or otherwise allowing the implementation of an activity.*	The Project involves activities that have the potential to pollute and/or degrade the natural environment, hence consideration of the NEMA would assist to avoid certain environmental impacts, or, where they cannot be altogether avoided, minimise or remedy them as much as practically possible

4 Assumptions, Limitations and Exclusions

This section provides assumptions, limitations and exclusions considered in undertaking this groundwater assessment:

- Baseline hydrogeological assessment, hydrocensus survey, groundwater quality assessment, drilling of monitoring boreholes, conceptual and numerical model update and impact assessment constitute the scope of the current study;
- It was assumed that no infrastructure will be constructed at Middeldrift, except for the proposed open pit, a soil stockpile and rock dump. The infrastructure at the existing NCC will be utilised for all other mining processes; and
- Previous hydrogeological studies and models were used as input into this assessment;
- For the modelling of groundwater impacts, impacts of adjacent mining activities were taken into account;
- Groundwater levels in the newly drilled boreholes, existing monitoring boreholes and hydrocensus boreholes were used to calibrate the model;
- It was assumed that the underground mine voids in the vicinity of and neighbouring Middeldrift will remain dewatered during the Middeldrift operational phase. This is an acceptable assumption as underground mines are currently not flooded, the proposed Life of Mine (LoM) for Middeldrift is relatively short and mining at Middeldrift is expected to commence in 2022.

- However, it was anticipated that these mining areas are flooded after closure of Middeldrift. This is a worst-case assumption with regards to post-closure contaminant plume movement and decant;
- Included were two options for mining: option 1 is a smaller open pit with a LoM of 11 years, option 2 is a larger open pit with a LoM of 14 years; and
- It was assumed that local groundwater levels are currently drawn down due to adjacent underground mining, and this will have a decreasing effect on inflows during the operational phase.

5 Details of Specialists

Details of the specialists involved in the current study are summarised in Table 5-1below:

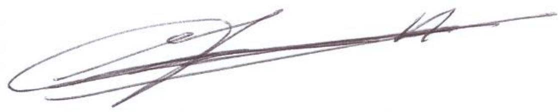
Table 5-1. Specialist Details

Report Writer	
Full Name of Specialist	Arjan van 't Zelfde
Highest Qualification	MSc. Soil Science & Hydrogeology
Years of experience in specialist field	16 years
Registration(s):	SACNASP 115656
Technical Review	
Full Name of Specialist	Andre van Coller
Highest Qualification	MSc. Hydrogeology
Years of experience in specialist field	13 years
Final Review	
Full Name of Specialist	Mia Smith
Highest Qualification	MSc Environmental Science
Years of experience in specialist field	14 years

5.1 Declaration of Main Specialist

I, Arjan van ‘t Zelfde, as the appointed specialist, hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent, other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity;
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.



Signature of the specialist

Jan Arie van ‘t Zelfde

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

18 June 2021

Date

6 Methodology

The methodology followed in this study is described in the following subsections.

6.1 Baseline Hydrogeology

6.1.1 Desktop Review

All existing relevant groundwater, surface water, geological and Geographical Information Systems (GIS) data and databases was gathered and reviewed. All potential risks, gaps and sources of contamination were identified during this phase. The data collected during this task was used to strategise the approach for the field investigations.

6.1.2 Hydrocensus and Groundwater Quality Assessment

A hydrocensus was conducted in close proximity to Middeldrift. During the hydrocensus all hydrogeological data and owner details, where applicable, of identified boreholes and springs were collected with the aim of obtaining baseline groundwater conditions. A total of three boreholes and one spring were assessed during the hydrocensus, in addition to four newly drilled boreholes. The groundwater quality interpretation included the historical data for the period January to December 2020 for 30 sampling points.

6.1.3 Geophysical Survey

A geophysical survey using electromagnetic and magnetic methods was conducted to survey target areas for drilling identified during the desktop study. Geophysics was conducted with the aim of identifying and locating drilling targets for geological logging and aquifer characterisation. Provision was made for four survey lines with an average length of 500 m for each line.

6.1.4 Drilling of Monitoring Boreholes

The geophysical data was interpreted and four drill targets were identified. The rotary air percussion method was used for drilling of the boreholes. The borehole drilling provided information on the underlying lithologies, water strikes/seepages and groundwater levels. The holes were drilled by a sub-contractor under supervision of a Digby Wells hydrogeologist. During drilling the boreholes were logged and all relevant hydrogeological data was gathered.

6.2 Conceptual Model

The conceptual model aims to describe the groundwater environment in terms of the source-pathway-receptor dynamics. Potential impacts on the environment were derived from the understanding of the relationship between these entities of the system. The conceptual model was used also as input for the numerical model.

6.3 Numerical Model

During this task, a numerical model was based on the conceptual model and data collected during the desktop review and field investigations. The conceptual model was encoded into the numerical model. The model was calibrated using the latest groundwater levels (steady state) from monitoring data, hydrocensus locations and newly drilled monitoring boreholes, together with historical knowledge of the adjacent mining areas. The calibrated model was utilised to run the required scenarios to determine the likely impacts associated with the project activities. The scenario modelling covered the operational phase and a period of 100 years post-closure.

6.4 Groundwater Impact Assessment

An impact assessment was undertaken based on the outcome of the numerical model, with recommended mitigation measures that may be required to address the groundwater impacts associated with the project. The impacts, mitigations and significance ratings before and after mitigation, along with recommendations for further work have been documented in this report.

7 Mining Activities

7.1 Historical Activities

The descriptions of historical activities include below are based on *"New Clydesdale Colliery Hydrogeological Study"* (GCS, 2014). Various historic mining activities have taken place within the NCC MR boundary and surrounding area, as shown in Figure 7-1. These activities included open pit mining of coal at Vaalkranz East (VKE), Vaalkranz North (VKN), Phase 4 and 5, Phase 9, Village pit and Haasfontein Phase I. All these open pits were rehabilitated at the time of the investigation. Over the past decade, numerous open pit mining sections have been developed. The open pits mainly targeted the No. 2 coal seam and the overlying No. 4 coal seam, where this was developed. The estimated mining duration per section is listed below:

- Open pit:
  - VKE: July 2002 - Nov 2004;
  - (VKN: Aug 2005 - Feb 2010;
  - Phase 4 and 5: 1988 - 1997;
  - Phase 9: 1988 – 1997;
  - Village pit: Jan 2006 - Aug 2006;
  - Haasfontein Phase I: Oct 2008 - Mar 2011; and
  - VKN mini pit (which later became the shaft for VKN underground): early 1997 - mid 1998.
- Underground:
  - VKN:- Late 1998 - Nov 2002;
  - Vaalkranz South (VKS): +/- 1948 - Feb 2007; and
  - Diepspruit: May 2009 – Present (this mining area is still actively mined and as such described under the current activities).

The VKN open pit targeted the No. 4 upper and lower seams, which was less than 9 m below surface in places. The separating layer above the underground, bord and pillar mined out No. 2 seam is ~17 m. The Haasfontein I open pit mined out both the No. 2 and No. 4 seams. The VKE, Phase 4 and 5, Phase 9 and Village pit sections mined the No. 2 seam. Underground mining was also conducted at VKN and VKS. Active mining activities at NCC (at the time of the investigation) includes underground coal mining at Diepspruit.

Various pollution control dams were constructed to address storm water management around NCC (Diepspruit shaft, plant area and rehabilitated VKE). In addition, a coal washing plant is in operation processing coal destined for the export and domestic markets. A discard facility has been established on Vaalkranz 29 IS, to store the low grade coal waste product separated during the washing plant process and covers an area of approximately 13 ha. Various methods of utilisation are being considered for the use of this low grade coal (SRK, 2011).

The VKS underground workings were stooped (at depth of approximately 30 – 90 m) in places.

Evidence of the stooping is visible on surface, including the formation of water holding depressions. Four shafts at VKN have been decommissioned and sealed off. These shafts are the VKN incline in the VKN mini-pit, two VKS incline and two VKS vent shafts. There were two active shafts at the time of the investigation at the Diepspruit section, including an incline shaft and a vent shaft.

Middeldrift is located adjacent to the Rietspruit/Phoenix Mine underground mine workings and is bounded by these mining areas on the north, west and eastern side of the proposed open pit as seen in Figure 7-1. These Rietspruit/Phoenix Mine underground mine workings are thought to be connected to rehabilitated open pit areas to the west and northeast of these underground workings. The long-term flooding status of these workings should be verified as interaction of mine water between the underground workings and the proposed Middeldrift open pit is likely.

7.2 Current Activities

The current mining activities within the NCC MR areas (Figure 7-2) consist of:

- Diepspruit Underground: Three board-and-pillar sections mining the No. 2 lower seam;
- Diepspruit West: Open pit truck and shovel mining operation; and
- Roodekop: Open pit truck and shovel mining operation.

Open pit mining from the Diepspruit West and Roodekop Resources is on-going and will continue until the reserves are depleted; after which mining will progress into Middeldrift. The box cut for Middeldrift will be created at the same time as when the coal is depleted at Roodekop. This will allow production to continue uninterrupted.

7.3 Proposed Activities

Middeldrift will be an open pit truck-and-shovel operation, focusing on the No. 4 upper and lower seams; No. 2 upper and lower seams; and the No. 1 and No. 1A seams. From the Middeldrift area, the coal will be transported to the NCC by truck via haul road. Run Of Mine (ROM) coal will be washed at the NCC coal handling and processing plant (CHPP). No new infrastructure is proposed to be constructed at Middeldrift.

Middeldrift is separated from the existing NCC open pit areas by the Steenkoolspruit. To protect this water course, it is intended that Middeldrift be mined as a separate open pit operation once the existing NCC areas have been mined out. This will require the diversion of the district road around the north of the existing Roodekop open pit in order to continue with mining. A bridge over the Steenkoolspruit will be constructed to gain access to Middeldrift. A preliminary infrastructure layout has been included as Figure 7-3.

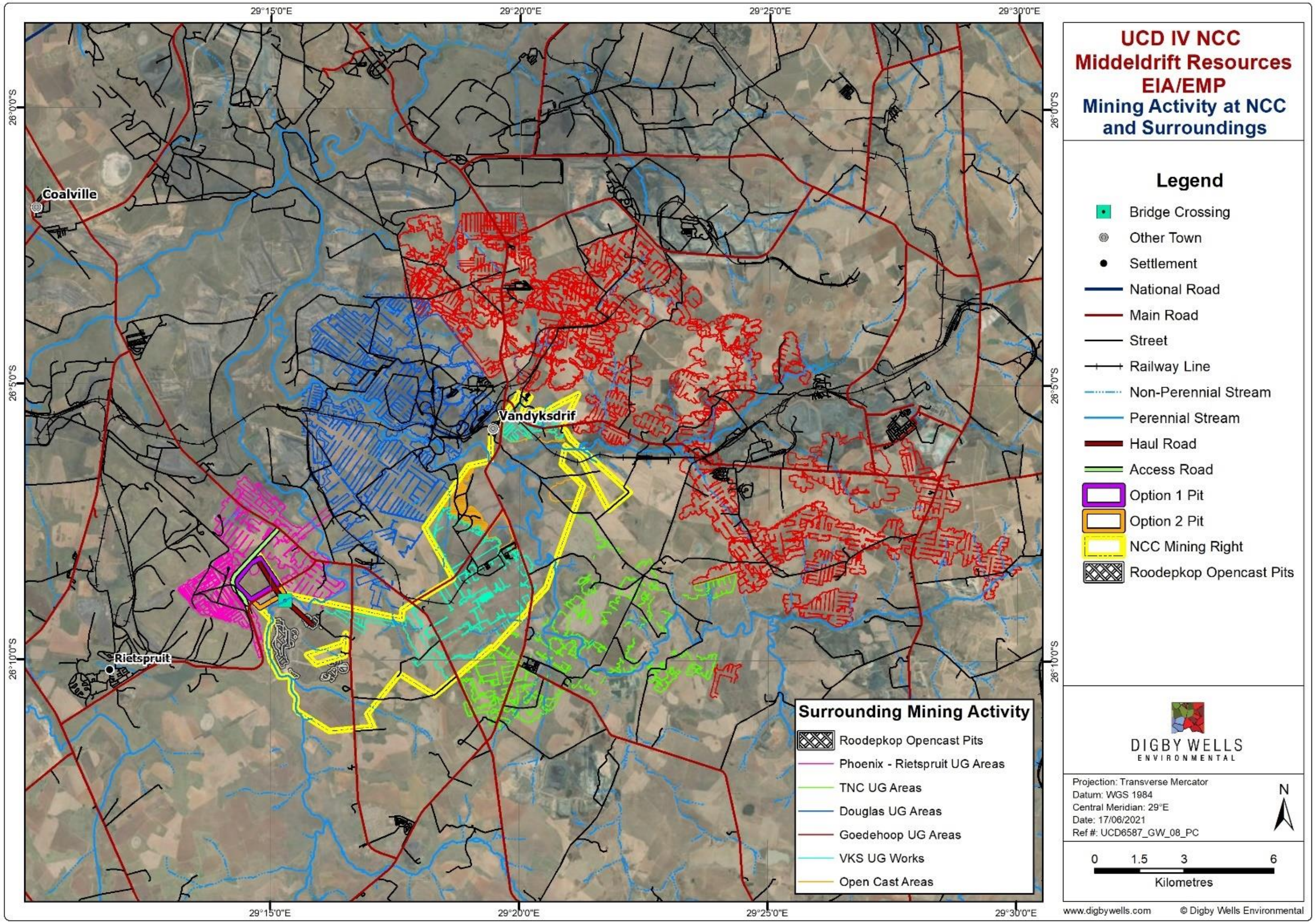


Figure 7-1: Mining Activities At NCC And Surroundings

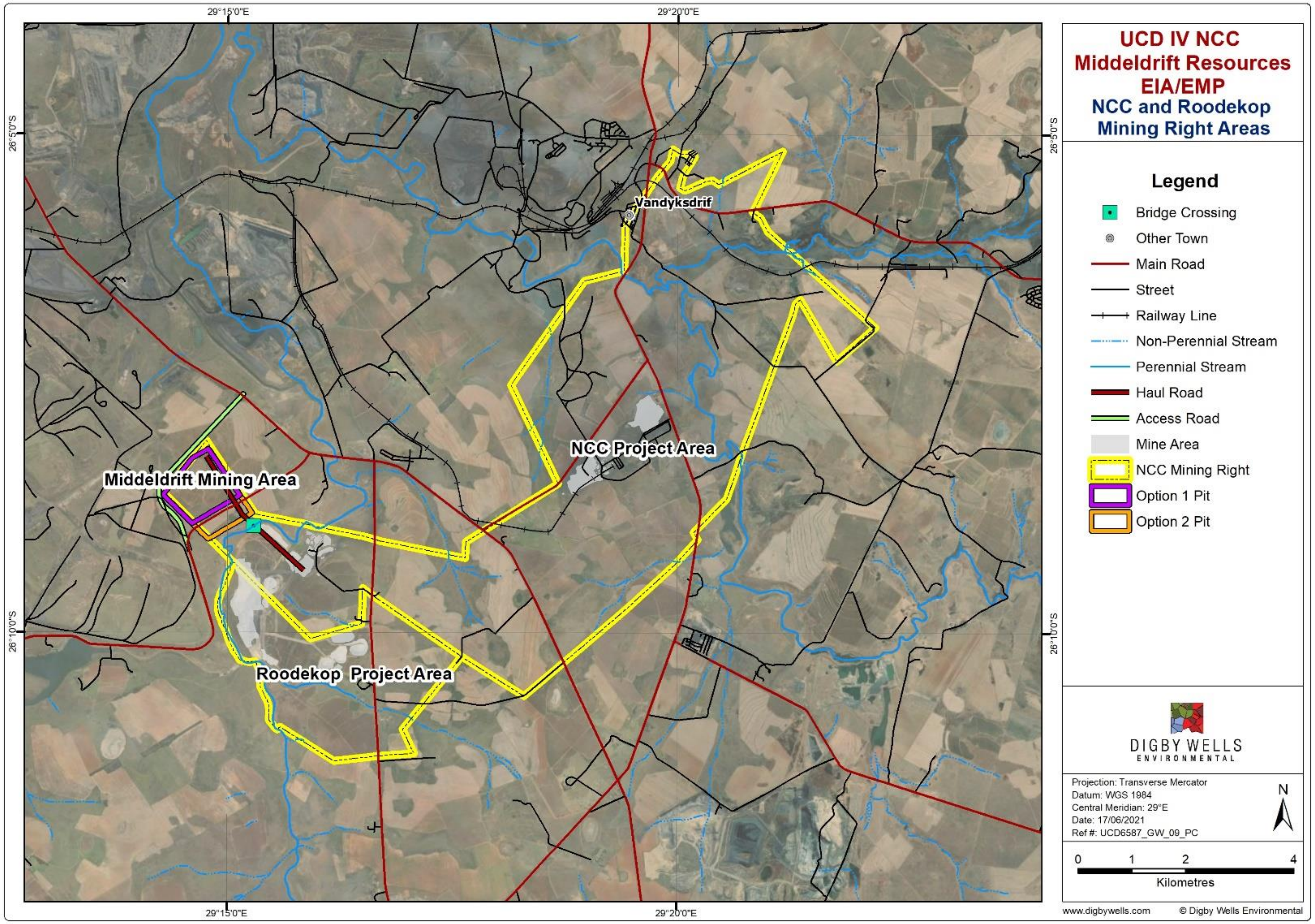


Figure 7-2: General Layout Showing The NCC And Roodekop Mining Right Areas

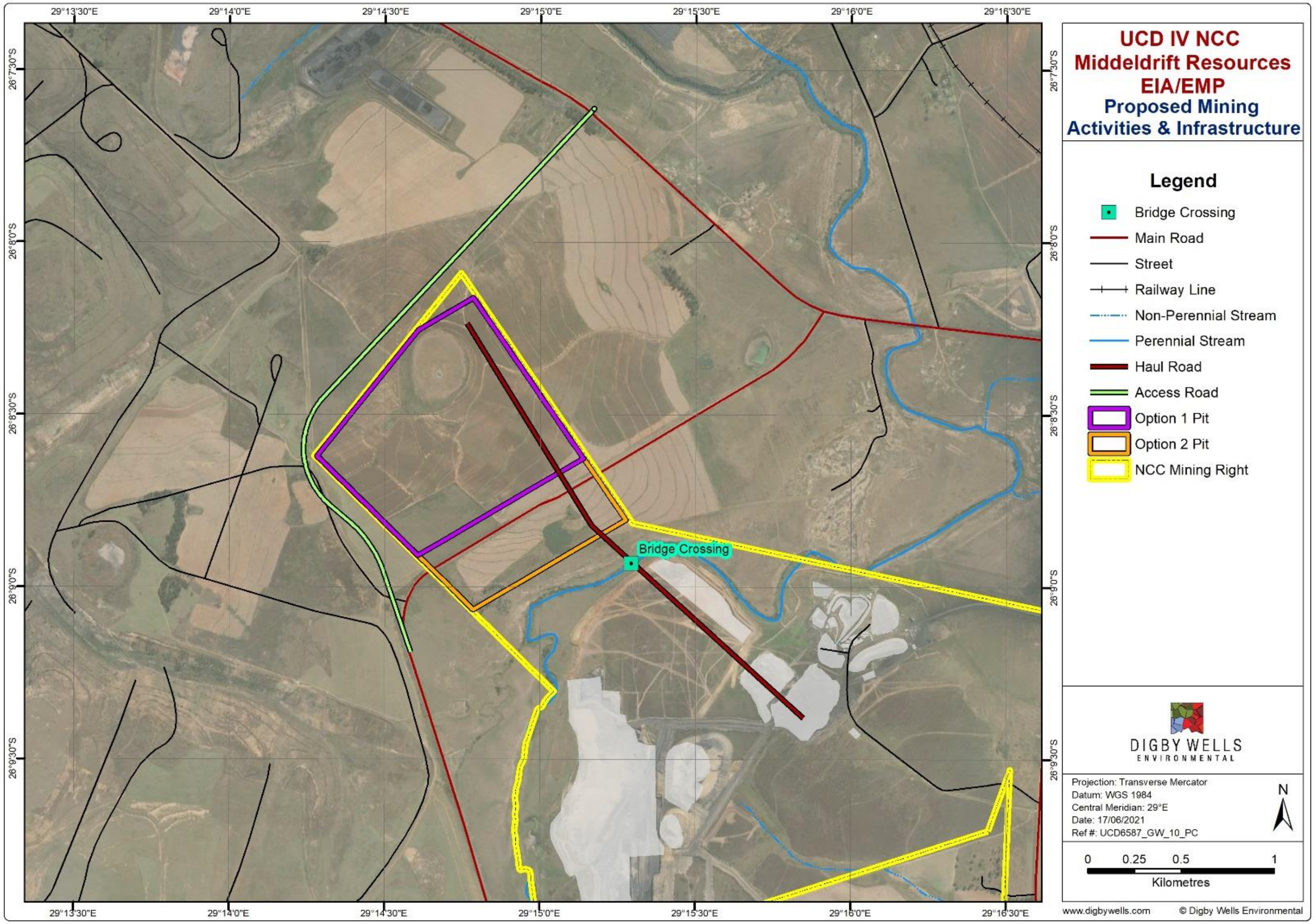


Figure 7-3. Middeldrift Proposed Mining Activities And Infrastructure.

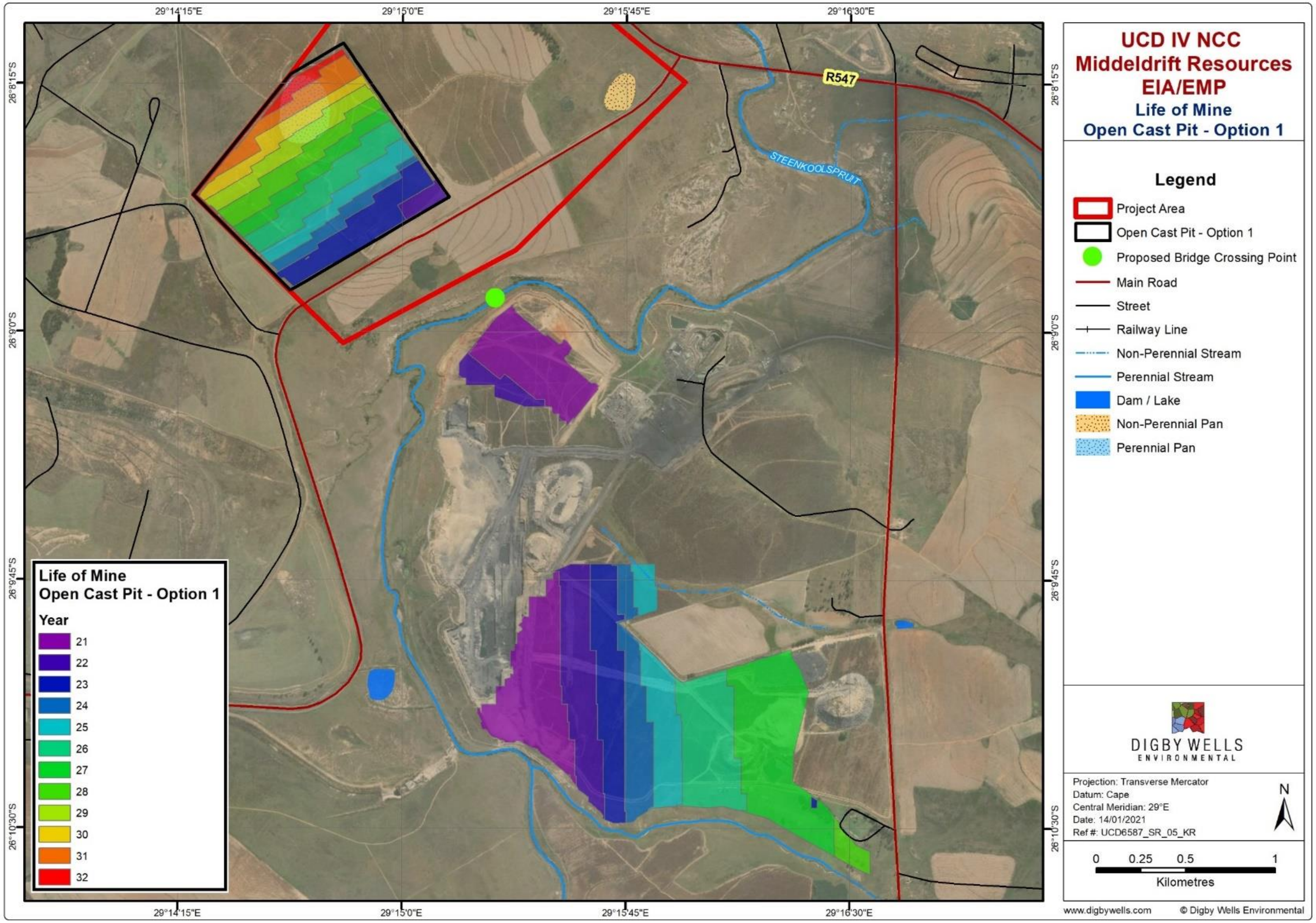


Figure 7-4. Middeldrift Proposed Yearly Mine Schedule– Option 1

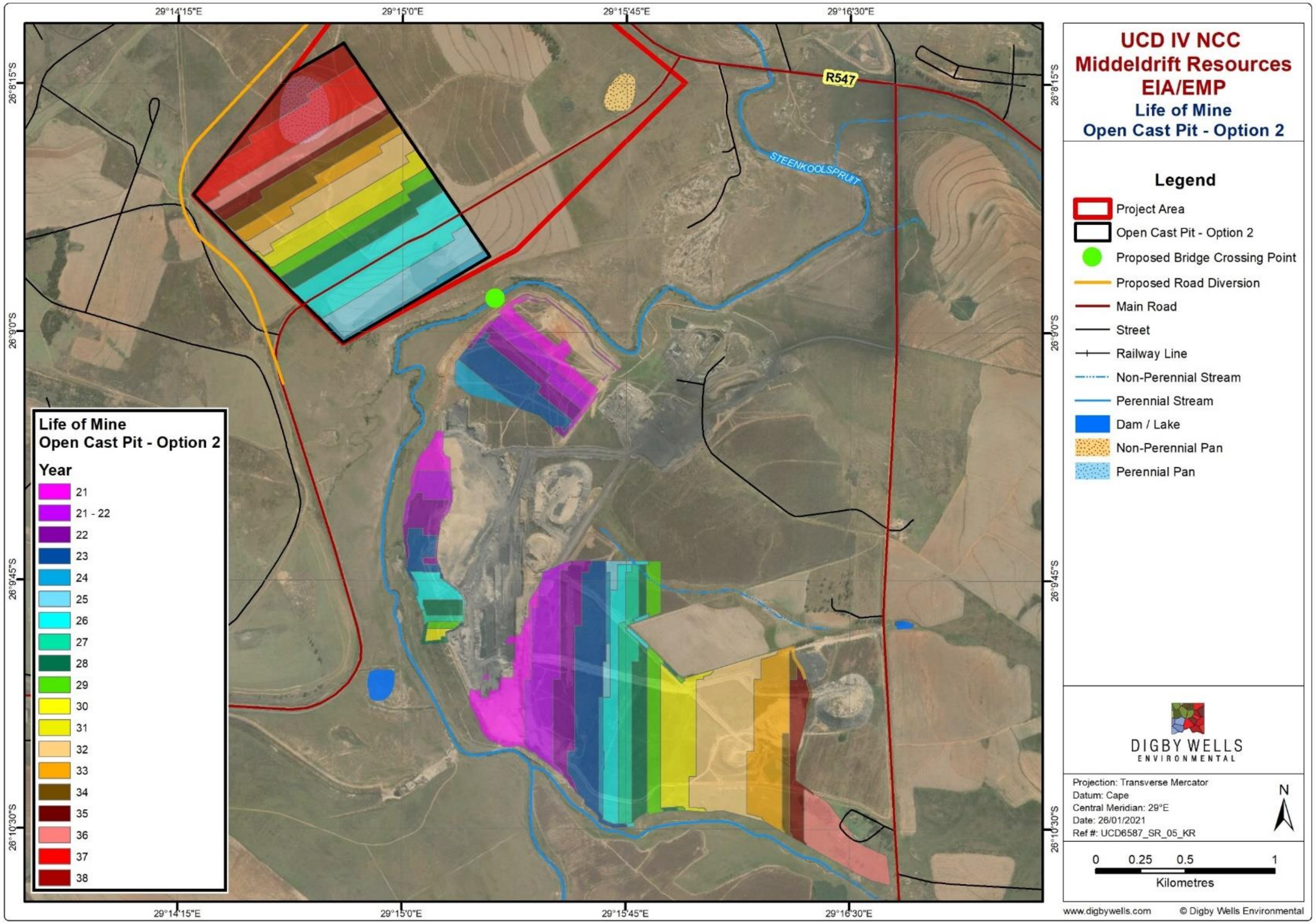


Figure 7-5. Middeldrift Proposed Yearly Mine Schedule – Option 2.

For the mining at Middeldrift to progress through the district road, it requires wayleave applications, decommissioning of the existing road and construction of a new road around the open pit. *Option 1* is based on the possibility of the wayleaves and diversion not being approved; while *Option 2* assumes that the road diversion will be permitted. See Figure 7-4 and Figure 7-5 for the respective options.

7.4 Surrounding Mining Activities

The descriptions of surrounding activities are based on *"New Clydesdale Colliery Hydrogeological Study"* (GCS, 2014). Several mines surround and border the NCC mining area as previously mentioned. Specific relevance are the flooded/partially flooded No. 2 seam underground workings neighboring the Diepspruit and VKS mines to the east (TNC) and to the west (Douglas). Based on a legal requirement, a barrier pillar should theoretically exist between the NCC and neighbouring mines. The location of these mines can be seen in Figure 7-1.

The Xstrata Phoenix Colliery is located to the west of NCC. It is unknown which seams are being mined, but it is likely to be the No. 1, 2 and 4 seams. The extent of mining is unknown.

To the north of the VKS and Diepspruit underground, the Douglas Colliery (Albion workings) is found. This section mined out the No.2 seam adjacent to NCC. It is unknown to what extent the underground was flooded. The Douglas open pits are found to the far north, adjacent to the Olifants River. It is reported that the underground section at Douglas will decant through an open pit at a level of 1 510 meters above mean sea level (mamsl; Hodgson, 2006).

The TNC colliery ceased mining operations in 1991. The disturbed areas were rehabilitated. The No. 2 coal seam was mined throughout the TNC area. In small areas, the No. 1 coal seam was also extracted. Mining methods used was bord-and-pillar extraction, followed by stooping in 21% of the underground area. Much of these stooped areas are in topographically low-lying areas (WRC, 2007).

The central portion of the TNC coal seam floor has a basin structure, with its lowest point underneath the TNC Village. The No. 2 seam floor elevation is in the order of 1 496 mamsl at the lowest point. The coal floor rises in all directions away from this point to attain a maximum elevation of 1 530 mamsl in the southeast. The other areas at TNC are separated from the main block through dolerite displacements. The depth of mining varies from as little as 6 m in the open pit areas of Block A, Block B & C and Block H to more than 100 m in the Welstand Block. The Welstand TNC block is the largest area and has been mined by bord and pillar methods adjacent to the NCC VKS workings. It has been reported that the TNC Welstand block will decant at a level of 1 531 mamsl near the Olifants River (WRC, 2007).

The Goedehoop Colliery is located to the north of the NCC mining areas. This large mining complex has mined No. 1 to No. 5 coal seams. No interaction between NCC and Goedehoop Colliery is likely to occur.

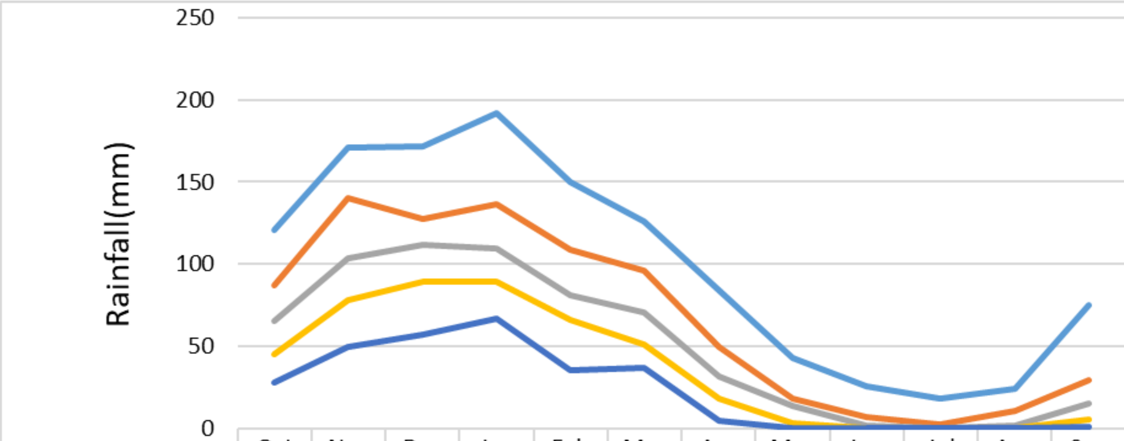
Of importance to the proposed mining activities at Middeldrift is that the proposed open pit is surrounded by other mining activities and is directly adjacent to the Rietspruit and Phoenix underground (to the southwest, northwest and northeast); and also in close proximity of the ongoing Roodekop open pit mining to the southeast, on the opposite side of the Steenkoolspruit.

Local groundwater levels and reserves at Middeldrift have already been impacted by adjacent underground mine voids (mining the No. 2 seam) and the current open pit mining (mining down to the No. 1 A seam). Mainly the underground mining activities which have not or have only been partially flooded, have already impacted on local groundwater levels. This needs to be taken into account when assessing the impacts of the activities at Middeldrift.

8 Baseline Description

8.1 Climate

The project area has a Mean Annual Precipitation (MAP) of 682 mm. The NCC operations fall within the summer rainfall region of South Africa, where more than 80% of the annual rainfall takes place between the months of October to March. Figure 8-1 depicts the likely monthly distribution of rainfall in the catchment. January as the wettest month has a 90th percentile of 192 mm and 10th percentile of 67 mm.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
90 Percentile	121	171	171	192	150	126	84	43	26	18	25	75
70 Percentile	87	140	127	136	108	96	50	19	7	3	11	29
50 Percentile	65	104	112	110	81	71	32	14	2	0	2	15
30 Percentile	45	78	89	89	66	51	18	3	0	0	0	6
10 Percentile	28	50	57	67	36	37	5	0	0	0	0	1

Figure 8-1: The Monthly Rainfall Distribution within the Quaternary Catchment B11E

8.2 Topography and Drainage

Middeldrift is located within the B11E quaternary catchment falling under the Olifants Water Management Area (Figure 8-2). The area is located predominantly on a topographical low within the catchment, with elevation ranging from approximately 1 529 mamsl to 1 574 mamsl. The B11E quaternary catchment is located within the Olifants River Catchment. Drainage within the project area is facilitated by the Steenkoolspruit, one of the major tributaries of the Olifants River (Figure 8-2).

The topography of the Middeldrift area, as depicted in Figure 8-3, ranges from high elevations on the south-west side of the Project area to low lying areas in the north-west and south towards the Steenkoolspruit. The Project area can be described as uneven slopes with moderate undulating plains running towards a low-lying valley (Steenkoolspruit) on the east and south of the Project area. Depressions/pans are scattered throughout the western and eastern side of the landscape. The elevation of the Project area ranges between 1 509 and 1 575 mamsl, which equates to a range of 66 m between the lowest and highest points of elevation within the Project area. The difference in elevation gives rise to a slope of between 0 and 23 degrees (°).

8.3 Land Use

The current land uses in the region include coal mining, farming, power generation facilities and small residential communities (Figure 8-4). The dominant land use within the Project area is cultivated land. Other land uses within the Project area include grassland and small areas are occupied by thickets/dense bush and wetland/ water areas.

8.4 Geology

8.4.1 Regional Geology

Middeldrift is located within the Witbank coalfield, which is within the Karoo Supergroup (Figure 8-5). All of the known coal deposits in South Africa are hosted in sedimentary rocks of the Karoo Basin, a large foreland basin which developed on the Kaapvaal Craton and filled between the Late Carboniferous and Middle Jurassic periods.

The Karoo Supergroup is lithostratigraphically subdivided into the Dwyka, Ecca and Beaufort groups and succeeded by the Molteno, Elliot, Clarens, and Drakensburg Formations. The coal ranges in age from early Permian (Ecca Group) through to Late Triassic (Molteno Formation) and is predominantly bituminous to anthracite in rank, which is classified in terms of metamorphism under influence of temperature and pressure.

The Karoo Supergroup within the project area comprises the Ecca Group and the Vryheid Formation. The base of the Karoo Supergroup is the Dwyka Group comprising of tillites that are fairly regularly deposited over the basin except for paleo-topographical highs. The Dwyka tillites are overlain by the Vryheid Formation of the Ecca Group which hosts the coal seams.

The Vryheid Formation consists of various sequences of stacked upward-coarsening depositional sequences of sandstone and siltstone with the various coal seams located within the alternating lithofacies (Figure 8-6). The sediments (the coal coal-bearing sandstones and siltstones) rest either conformably on diamictite and associated glaciogenic sediments of probable Dwyka age, or unconformably on basement rocks. The Ecca Group sediments overlie the Dwyka Group. The geology can be stratigraphically classified as indicated in Table 8-1.

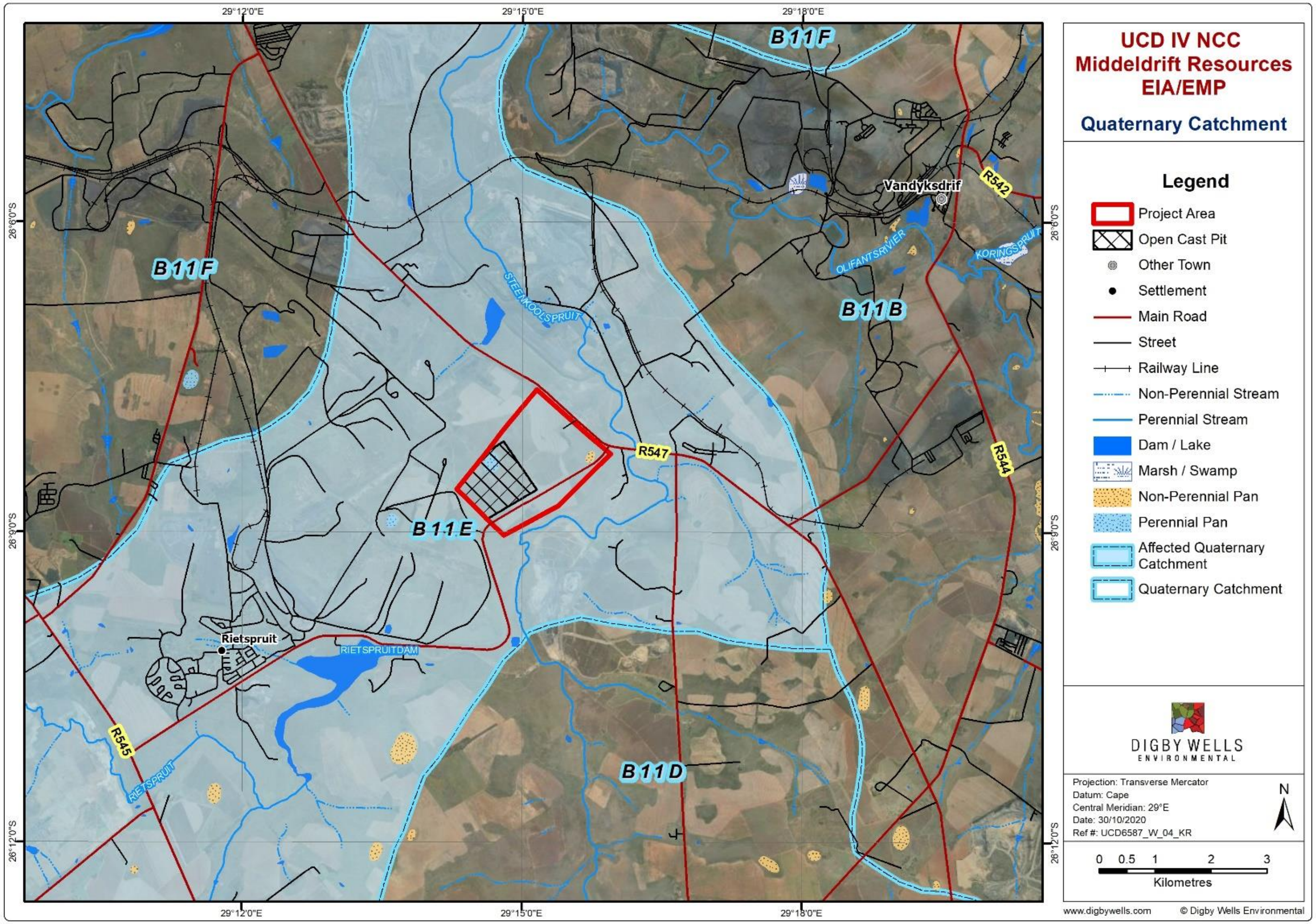


Figure 8-2: Hydrological Setting of Quaternary Catchment B11E

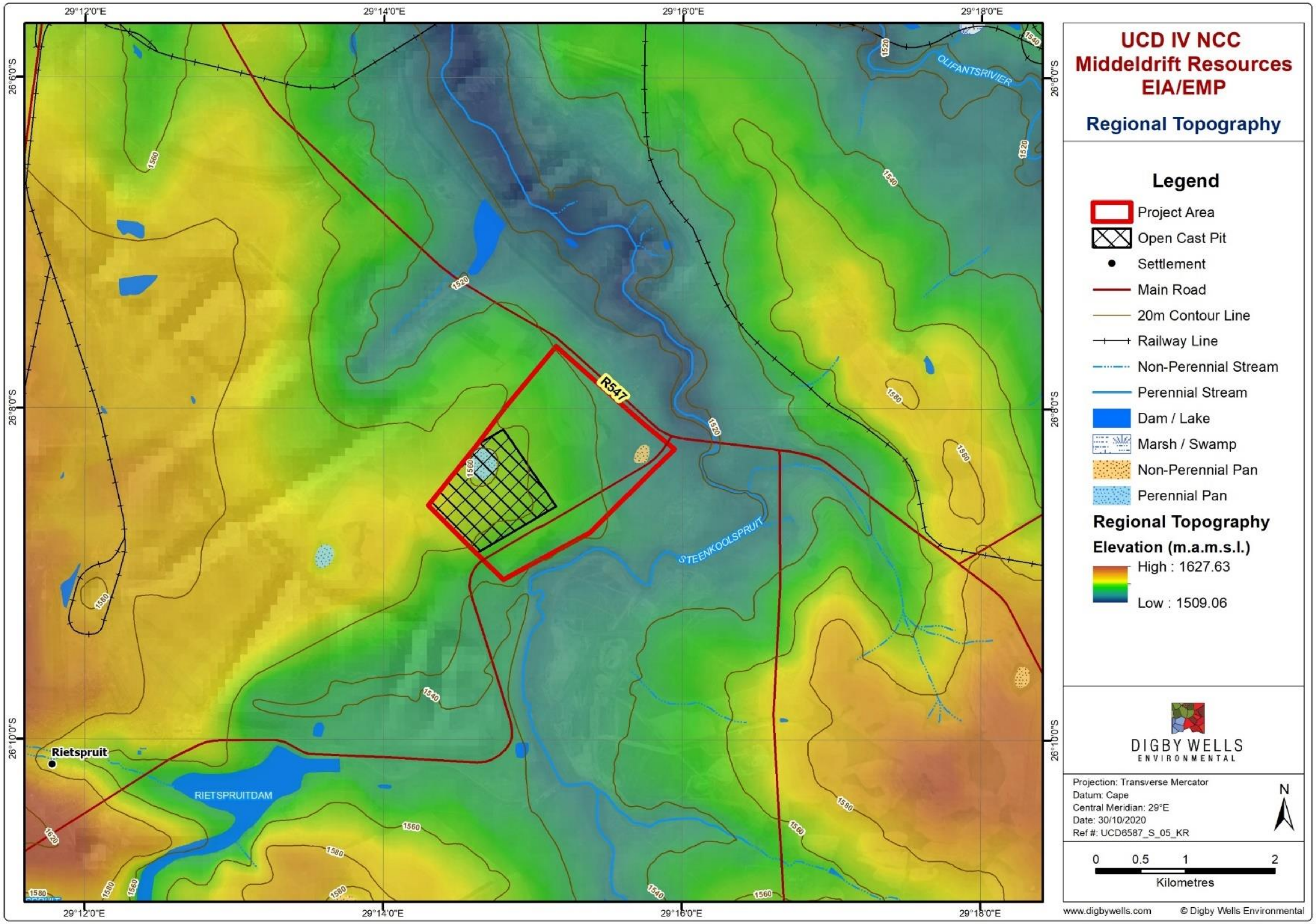


Figure 8-3: Topography For The Project Area

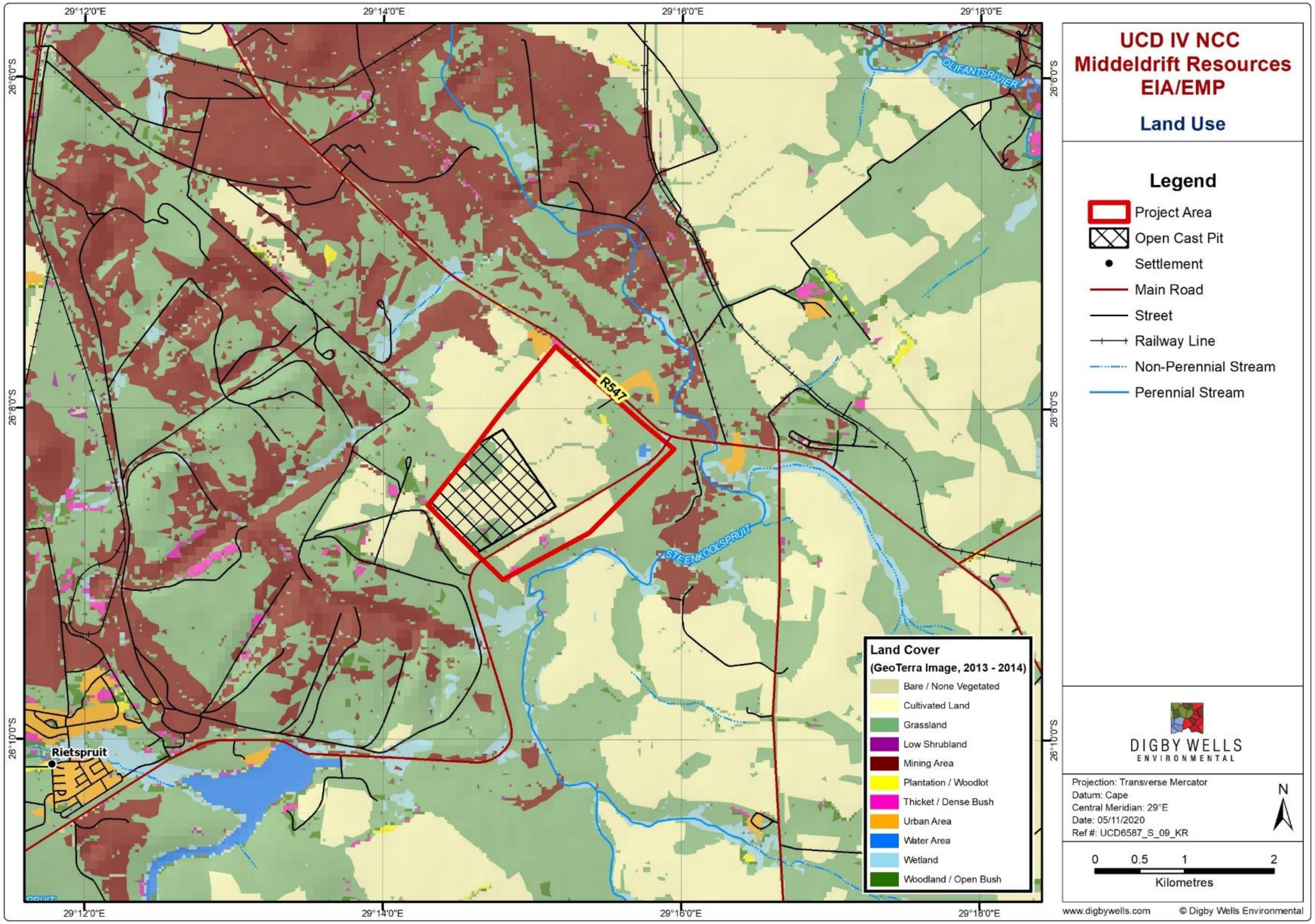


Figure 8-4: Land Use For The Project Area

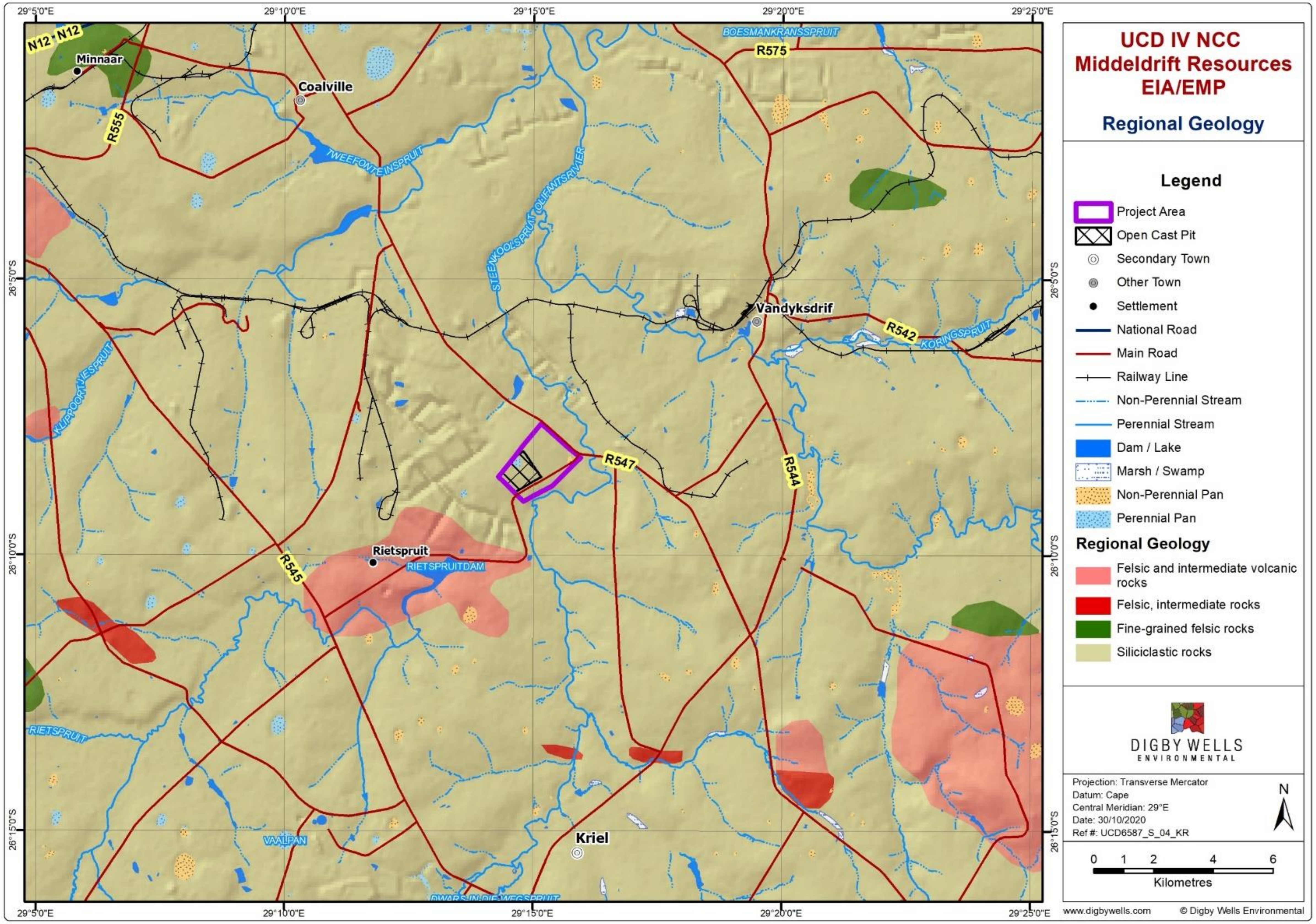


Figure 8-5: Geology For The Project Area

During the Jurassic period, dolerite dykes and sills intruded into the Karoo Supergroup as part of the Karoo dyke swarm (originating from the Karoo Large Igneous Province). These dykes and sills act as important geological structures which can divert and/or impede groundwater movements. The tendency of dolerite sills to migrate to differing stratigraphic levels has resulted in the coal seam displacement throughout the Karoo Coalfields.

Table 8-1: Stratigraphy Of The Regional Geology

	Subgroup	Lithology	Formation
Karoo Supergroup	Upper Ecca	Sandstones	Volksrust
	Middle Ecca	Sandstones	Vryheid
		Shales	
		Coal	
	Lower Ecca	Shale	Pietermaritzburg

8.4.2 Local Geology

The Project area is located in the Witbank coalfield which is part of the Karoo basin. Regionally, the Karoo Supergroup was deposited on undulating, diabase and felsite rocks of the Transvaal Supergroup. This pre-Karoo floor had a significant influence on the distribution and thickness of many of the sedimentary formations including the coal seams (GCS, 2014). The extent of the coal units are largely controlled by the pre-Karoo topography. The sedimentary units of the Ecca Group are generally horizontal, with low frequency undulations and a gentle regional dip to the south. There are five coal seams of the Witbank coalfield numbered from the base upward, with No. 1 at the base and No. 5 closest to the surface.

The coal is contained within a 70 m thick succession of sandstone, mudstone, siltstone and shale. Prominent marker units are glauconitic sandstones which occur above the No. 4A and No. 5 seams; and the lithologies overlying the No. 5 seam is mostly arenaceous (Groundwater Square, 2007). Alluvial deposits are prevalent along the rivers and streams in the low lying area. The distribution of the No. 3, 4 and 5 coal seams are limited by the topography, while the distribution of the lower seams (No. 1 and No. 2) n is largely controlled by the pre-Karoo topography. The parting thickness between the seams is generally consistent (Groundwater Square, 2007).

Mining is proposed to extend to the No. 1A coal seam in the Project area and the dip of the seams is therefore assumed to be near horizontal. An illustration of the coal seams at the Roodekop mining area is shown in Figure 8-6.

8.4.3 Geological Structures

Dolerite intrusions as sills and feeder dykes are regionally common in the area. The sills vary from being transgressive to concordant and caused displacement of the host rock. No significant dolerite intrusions are however noted in the geological maps or boreholes logs of the adjacent Roodekop 63 IS area. Although faulting on a regional scale is evident within the surrounding area, faulting is not evident for the Project area and no major continuous zones of preferential flow, such as dolerite dykes and sills, were identified (GCS, 2014).

Higher yields noted for borehole RBH5 (See Section 8.5.2) were assumed to be due to intersection of a fault. Figure 3-4 shows a general stratigraphic column for the Roodekop mining area, adjacent to the Project area.

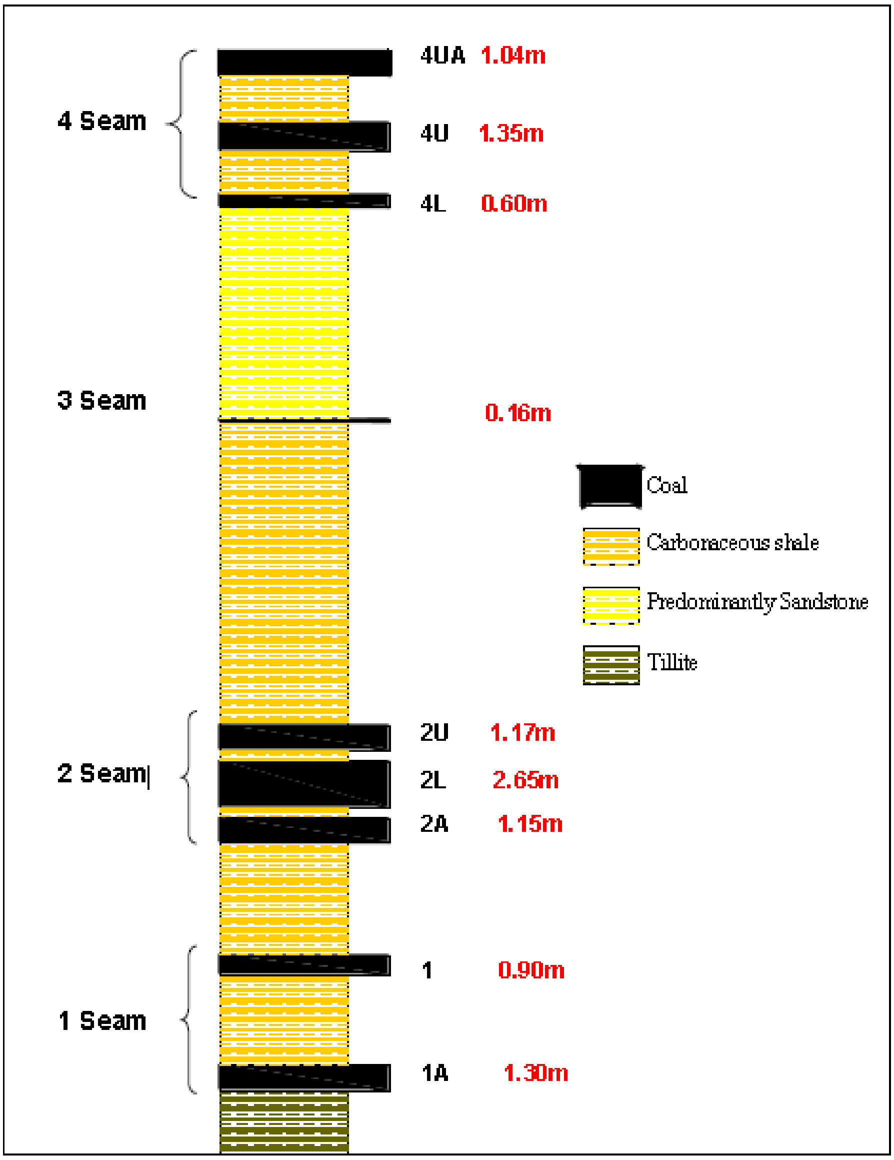


Figure 8-6: Stratigraphic Column for the Roodekop Area (Source: SRK, 2016).

8.5 Hydrogeology

8.5.1 Aquifers

The aquifers at for the Roodekop mining area were conceptualised by Digby Wells (2011) to be composed of four units: the shallow weathered Karoo, the intermediate fractured Karoo, the Dwyka tillite and the fractured igneous basement aquifer. Below a more detailed description of these aquifers, based on Digby Wells (2011) and GCS (2014).

8.5.1.1 Shallow Weathered Aquifer

The weathered material in the shallow weathered aquifer consists mostly of decomposed and highly weathered coarse-grained sandstones, with shales and siltstones in some areas. The depth of weathering encountered during drilling was observed to be between 6 and 17 mbgl. The sustainability in terms of aquifer yields of the shallow weathered aquifer is dependent on the effective recharge, which is the portion of rainfall that infiltrates through the soil and eventually reaches the saturated zone.

Hodgson (2006) reported that the aquifers in the Project area were not high yielding, with the highest reported yield of 5 l/s associated with a dolerite dyke. The typical yields associated with the sedimentary formations were < 0.5 l/s, and in the order of 1 – 2 l/s where dykes were intersected.

The aquifer transmissivity of the weathered material was estimated to be between 0.5 and 1.5 m^2/day.

8.5.1.2 Fractured Aquifer

The fractured aquifer consists of an interlaminated sequence of sandstone, shale, carbonaceous shale and coal. The pores within these sediments are well cemented and generally do not allow for any significant permeation of water. the main groundwater movement within this aquifer is therefore along secondary structures such as fractures, cracks and joints. However, not all secondary structures are water bearing. The apertures of water bearing structures open to flow are relatively small and therefore have characteristic low hydraulic conductivities.

Of all the fractured sedimentary layers the coal seams often show the highest hydraulic conductivity. Aquifer tests conducted within this aquifer indicated a low overall hydraulic conductivity.

8.5.1.3 Dwyka Tillite

The Dwyka tillite unconformably overlies the basement rocks and, where present, forms a hydraulic barrier between the overlying mining activities and the basement aquifer, due to its low hydraulic conductivity. The aquifer permeability of the Dwyka tillite was estimated between 0.0002 and 0.0148, with mean value of 0.0034 m/d (Hodgson & Krantz, 1998).

8.5.1.4 Basement Aquifer

The basement aquifer is composed of Rooiberg felsites, characterised by low yielding fractures. However, higher yields are expected in areas where pre-Karoo diabase intersects the basement aquifer. A yield of 2.5 l/s was measured in a borehole in close proximity to the Project Area, which was drilled into a diabase intrusion.

The basement aquifer is characterised by low recharge because of the overlying Dwyka Tillite. Higher recharge to the basement aquifer is possible in areas where basement rocks outcrops are visible.

8.5.2 Aquifer Parameters

8.5.2.1 Hydraulic Conductivity

Aquifer parameters were estimated during previous investigations by GPT (2006) and Groundwater Square (2007). Based on these studies, aquifer permeabilities typically ranges over several orders of magnitude and were approximated as follows (Groundwater Square, 2007):

- Overburden material (10 m/day to 0.001 m/day);
- Fractured rock (0.1 m/day to 0.001 m/day);
- Coarser sediments (0.1 m/day to 0.01 m/day); and
- Coal seams (0.001 m/day to 0.01 m/day).

Aquifer testing was carried out by Digby Wells in 2011 on five monitoring boreholes in the Roodekop mining area. The results are as shown below, based on one step/constant discharge/recovery test suite and four slug tests.

Table 8-2: Aquifer Testing Results – Digby Wells, 2011

Borehole ID	RBH1	RBH2	RBH3	RBH4	RBH5
Aquifer test conducted	Slug test	Slug test	Slug test	Slug test	SDT,CDT, RT
Thickness open to flow based on screen (m)	28	28	16	28	24
Hydraulic conductivity k (m/d)	0.016	0.054	0.004	0.031	-
Transmissivity T (m^2/d)	0.44	1.51	0.06	0.88	9.3

A total of 6 new monitoring boreholes were drilled by GCS in close vicinity of the NCC discard dump (GCS, 2014). Deep and shallow wells were drilled to depths of 46 m and 15 m, respectively. No major water strikes were encountered during drilling, only seepage. Seepage was generally found at a depth of 10 to 12 mbgl. Constant rate pump tests with recovery measurements were conducted on the deep boreholes (i.e., NCCB9D, NCCB10D and

NCCB11D). The shallower boreholes were pumped in order to measure their recovery. The results of the aquifer pump tests are shown in Table 8-3 and Table 8-4. The results showed the boreholes were low yielding. Borehole NCCB11 had a poor recovery even after 13 hours, further substantiating a generally low yielding aquifer.

Table 8-3: Results Of Historical Aquifer Tests (GCS, 2014).

BH number	Constant discharge test duration (min)	Pump rate/ Yield l/s	Initial WL	Recovery Period (min)	Recovery %	Transmissivity (m^2/d)	
						Early T	Late T
NCCB9D	60	1.25	3.14	960	87.22	1.7	0.33
NCCB10D	20	0.62	6.85	900	96.2	4	0.26
NCCB11D	7	1.3	10.4	780	32.1	0.95	_

Table 8-4: Results Of The Recovery Tests Of Shallow Boreholes (GCS, 2014)

BH number	Initial WL	Recovery Period (min)	Recovery %	Transmissivity (m^2/d)
NCCB9S	3.30	540	64.96	0.12
NCCB10S	7.06	300	96.97	4
NCCB11S	3.5	70	100	0.2

Table 8-5 below shows a comparison between the aquifer tests done as part of all available previous studies. The estimated hydraulic conductivity from the aquifer tests correlated well and show aquifer hydraulic conductivity values to be in the expected range of 10^{-1} to 10^{-3}m/d for Karoo aquifers. The values below, based on all previous studies, show the overall low potential of the aquifers, as is also stated in (Hodgson, 2006).

Table 8-5: Comparison Of Aquifer Testing Results

Aquifer parameter	Digby Wells, 2011	Groundwater Square (2007)	GPT (2006)	GCS (2012)
Hydraulic conductivity (m/d)	0.004 – 0.05	0.001 - 0.05	0.002 - 0.02	0.006 - 0.2

8.5.2.2 Groundwater Recharge

Groundwater recharge in the Karoo fractured aquifer ranges from 1 to 3%, based on previous experience and other studies within the Karoo coal fields. For the NCC area, recharge from rainfall to the weathered aquifer was estimated to be ~3% of MAP (GPT, 2006). Studies by Hodgson (2006) and Groundwater Square (2007) propose a range of recharge values for NCC based on different mining methods and coal seam depths. Based on the various previous studies, the estimated recharge value for NCC approaches ~2% of annual rainfall and as such, a recharge value of 2.3% MAP was used for the latest hydrogeological study (GCS, 2014).

8.5.3 Groundwater Use / Potential Groundwater Receptors

The Ecca Group is not known for the development of major aquifers, but occasional high-yielding boreholes may be present. The aquifers that occur in the area can therefore be classified as minor aquifers (low yielding), but of high importance (Parsons, 1995). Groundwater use in the area is mainly for domestic and stock watering purposes. In general, only about 30% of the boreholes are in use and where in use they serve as a sole source of reliable and clean domestic water (SRK, 2019).

8.5.3.1 Historical Data

Historical hydrocensus data was sourced from Digby Wells (2011) and GCS (2014) (Figure 8-7). Digby Wells (2011) reported that a number of privately owned boreholes in the wider region were not in use at the time of the 2011 study.

As described in GCS (2014) numerous previous hydrocensus investigations for NCC have been carried out (GPT, 2006; Groundwater Square, 2007; and GCS, 2009, 2011, 2012 and 2014). However, these hydrocensus investigations as well as the hydrocensus done by Digby Wells focused more on the NCC and Roodekop mining areas, east of Middeldrift.

Based on the previous hydrocensus data, there are no privately owned boreholes within the Middeldrift area. Regionally, groundwater is used for livestock watering, crop irrigation and domestic purposes. However, the low population density and low aquifer yield limit large-scale groundwater abstraction for irrigation and/or other uses.

As a result, the groundwater resource is fairly under-utilised (Digby Wells, 2011). It is also anticipated that existing and historical coal mining, as well within as outside the NCC and Roodekop mining areas, have dewatered the regional aquifer to some extent and as such, it is anticipated that groundwater will be less utilised.

8.5.3.2 Current Data

Based on the updated hydrocensus (Figure 8-8), the closest groundwater users are two boreholes approximately 1 200 m northeast of the proposed mining area. In addition, an unused spring is present in the same area close to the Steenkoolspruit. This confirms the low density of groundwater use in the vicinity of Middeldrift.

Please refer to Appendix B for details of the current hydrocensus survey.

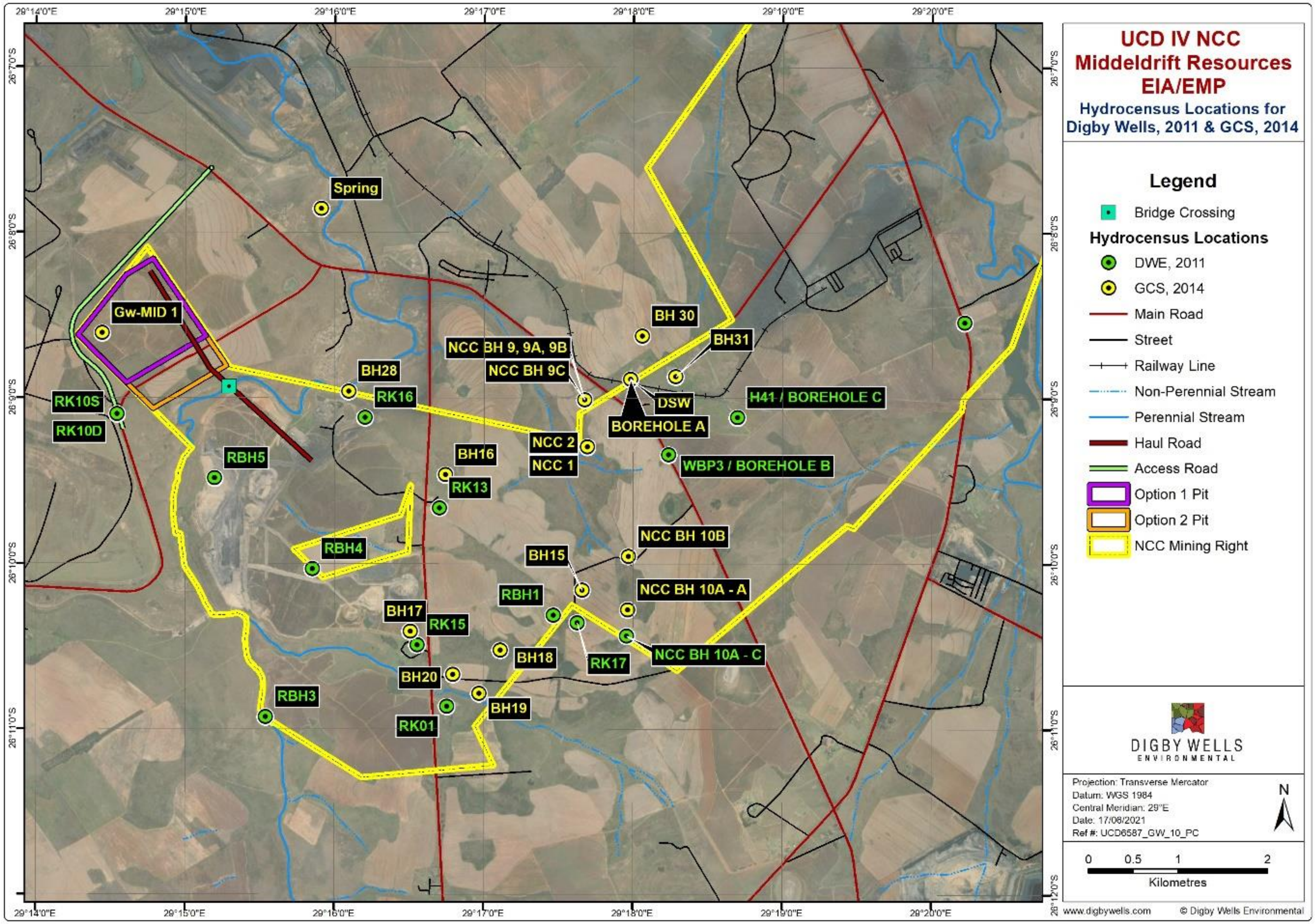


Figure 8-7: Historical Hydrocensus Locations for Digby Wells, 2011 and GCS, 2014 (Source: SRK, 2016)

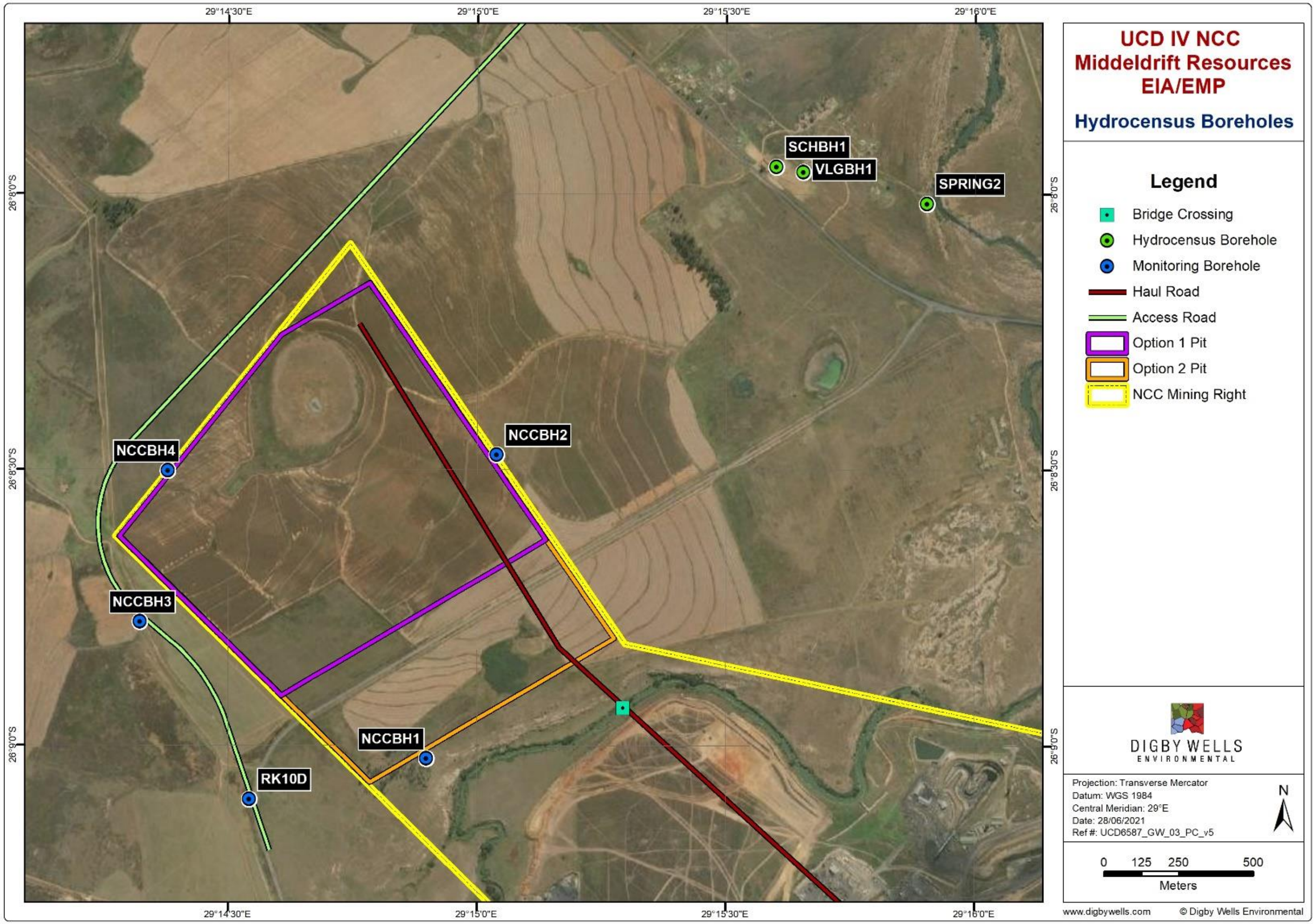


Figure 8-8: Current Hydrocensus Locations and Newly Drilled Boreholes

8.5.4 Groundwater Levels

8.5.4.1 Historical Data

Water level data was extracted from GCS (2014). GCS reported on monthly groundwater level monitoring data for the period between 2007 to 2014. The correlation of the groundwater level data is shown in Figure 8-9. The monitoring borehole locations in 2014 were very similar to those part of the current monitoring network.

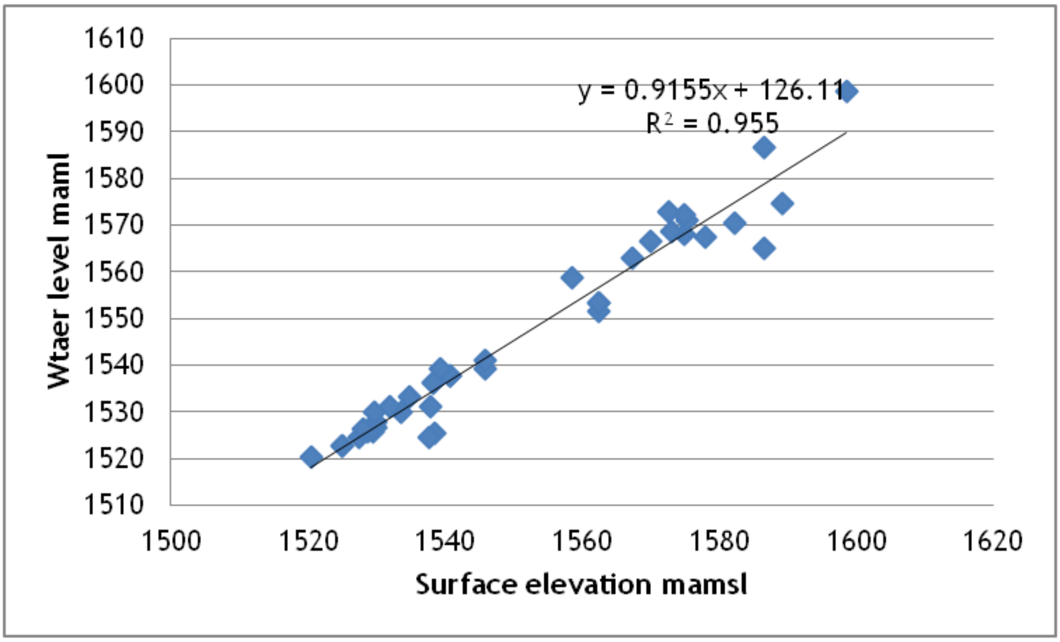


Figure 8-9: Bayesian Correlation (Source: GCS, 2014)

Based on the GCS hydrocensus and monitoring data the groundwater level varied between 0 mbgl (spring) and 22 mbgl, with an average of ~5 mbgl. A static water level of 12.5 mbgl was reported in monitoring borehole RBH5 by Digby Wells in 2011 which falls within this range. (GCS, 2014) concluded that there is a generally good relationship between topography and the static groundwater level as illustrated in Figure 8-9 above.

It is therefore feasible to use the relationship between topography and the phreatic level to determine historical ambient groundwater levels in areas of sparse data. As the Steenkoolspruit is perennial, it is assumed that groundwater contributes baseflow to the Steenkoolspruit.

However, dewatering and subsequent re-watering of existing and historical mine workings in the areas around the Project area are considered to have affected local groundwater levels. The outliers as noted in GCS (2014) suggest that current dewatering activities are causing local groundwater drawdown and/or local groundwater levels are still recovering due to historical dewatering activities. Deeper boreholes drilled into the VKS underground had water levels ranging between 71 and 83 mbgl (GCS, 2014), with the VKS workings in the process of being flooded. Local groundwater flow directions at NCC are therefore assumed to mainly be towards the VKS workings. The proposed mining of the open pits at the adjacent Roodekop mining area and current mining at the NCC are anticipated to further affect local groundwater flow directions.

8.5.4.2 Current Data

Based on the most recent ground water level monitoring data for the NCC mining area, the Roodekop mining area; and data from the recent hydrocensus and the newly drilled boreholes around Middeldrift, a 98% correlation between groundwater levels and surface elevations was derived, with exception of two boreholes (Borehole A and B – these are likely drilled into the VKS underground void, as they are similar in depth as what was indicated for the VKS underground in GCS (2014)).

This would indicate that regionally groundwater flow directions follow topography, with exceptions of areas with underground voids, where groundwater levels can be significantly drawn down. These points would divert significantly from this correlation.

Groundwater levels measured for 2020 and in the first quarter of 2021 are provided in Table 8-6. The levels ranged between 0 mbgl and 83.9 mbgl with an average level of 10.35 mbgl, in line with previous studies.

The groundwater elevation trend is presented in Figure 8-10. The trends indicate relatively stable groundwater elevations with seasonal variations present in the majority of the boreholes. Only BHA, BHB and NCCBH10B have shown groundwater depths outside expected levels, likely related to underground mining.

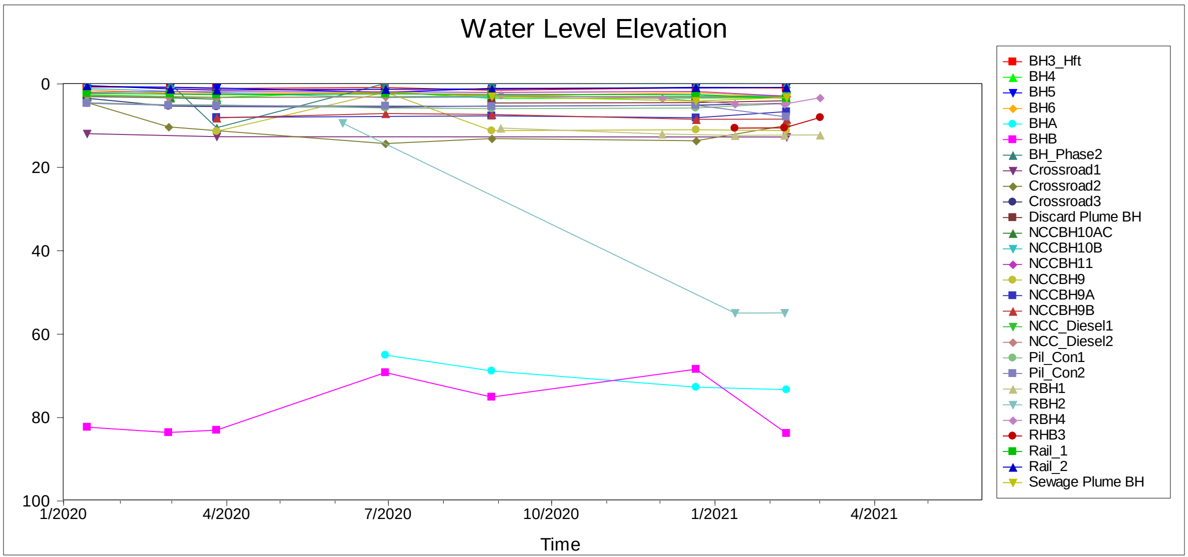


Figure 8-10: Water Level Depth Trend (in mbgl)

Table 8-6: Groundwater Level Measurements

Site ID	Ave. Water Level	Min. Water Level	Max. Water Level	Q1 2020 Water level (mbgl)	Q2 2020 Water level (mbgl)	Q3 2020 Water level (mbgl)	Q4 2020 Water level (mbgl)	Q1 2021 Water level (mbgl)
RBH1	11.68	10.65	12.31	-	-	10.65	12.09	12.31
RBH2	9.49	9.49	9.49	-	9.49	-	-	Dry
RHB3	7.28	2.69	9.58	-	2.69	9.55	9.58	-
RBH4	3.23	2.74	3.55	-	-	2.74	3.55	3.4
RBH5	-	-	-	-	-	-	-	Destroyed
NCC_Diesel1	3.18	2.91	3.29	3.29	3.23	2.91	3.28	-
NCC_Diesel2	3.19	2.97	3.36	3.36	3.17	2.97	3.25	-
NCCBH11	2.2	1.9	3.02	1.99	1.99	2.12	1.9	3.02
NCCBH9	9.43	2.05	11.46	11.46	2.05	11.29	11.08	11.29
GW_MID1				-	-	-	-	-
Crossroad1	12.75	12.73	12.82	12.73	-	-	-	12.82
Crossroad2	12.53	10.06	14.38	11.31	14.38	13.18	13.7	10.06
Crossroad3	5.3	4.73	5.63	5.52	5.63	5.42	5.2	4.73
Pil_Con1	5.53	4.78	6	5.12	5.88	6	5.88	4.78
Pil_Con2	5.87	5.2	7.97	5.29	5.38	5.5	5.2	7.97
BHA	70.06	65.11	73.41	-	65.11	68.93	72.8	73.41
BHB	76	68.5	83.88	83.1	69.3	75.2	68.5	83.88
BHC	-	-	-	-	-	-	-	-
NCCBH9A	7.71	6.74	8.2	8.15	-	7.76	8.2	6.74
NCCBH9B	8	7.18	8.6	8.26	7.18	7.42	8.6	8.54
NCCBH9C	-	-	-	-	-	-	-	-
NCCBH10B	2.85	2.26	3.37	2.26	3.37	-	-	2.91
Rail_1	2.79	2.48	3.52	2.71	2.48	2.59	2.65	3.52
Rail_2	1.23	0.93	1.56	1.56	1.39	1.31	0.93	0.98
NCCBH10AB	-	-	-	-	-	-	-	-
NCCBH10AC	-	-	-	-	-	3.75	-	-
BH2_Hft	-	-	-	-	-	-	-	-
BH3_Hft	1.17	0.98	1.59	1.2	0.98	1.59	1	1.06
BH4	3.12	1.93	3.55	3.29	1.93	3.55	3.48	3.36
BH5	1.26	0.91	2.08	1.07	2.08	1.16	1.08	0.91

Site ID	Ave. Water Level	Min. Water Level	Max. Water Level	Q1 2020 Water level (mbgl)	Q2 2020 Water level (mbgl)	Q3 2020 Water level (mbgl)	Q4 2020 Water level (mbgl)	Q1 2021 Water level (mbgl)
BH6	2.6	2.23	3.12	2.48	2.23	2.93	2.24	3.12
BH_Phase2	2.12	0	10.59	10.59	0	0	0	0
Sewage Plume BH	3.54	3.08	4.2	-	-	3.08	4.2	3.33
Discard Plume BH	4.46	4.12	4.66	-	-	4.66	4.6	4.12

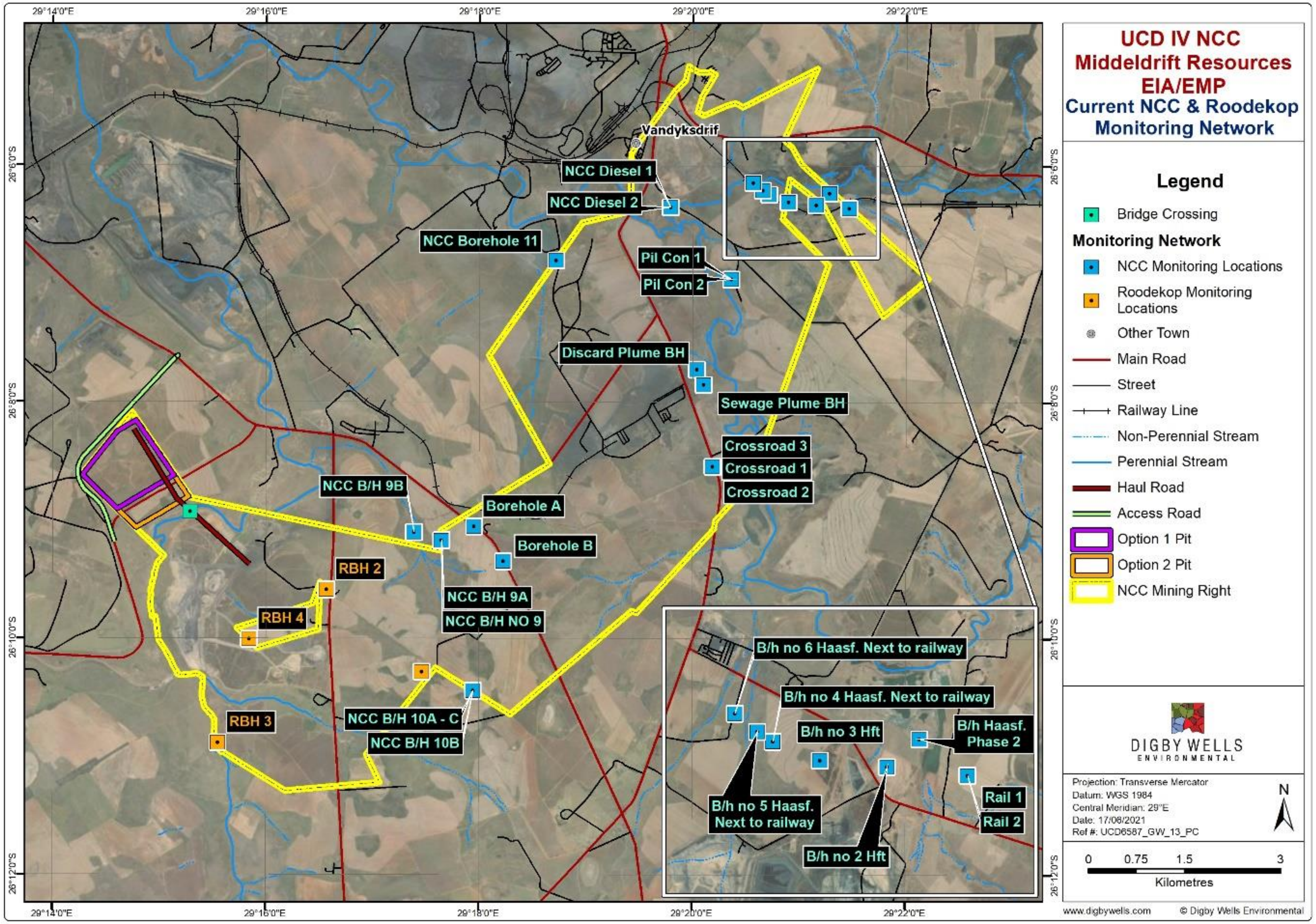


Figure 8-11: Current NCC and Roodekop Monitoring Boreholes (Source: Ankone Consulting, 2020)

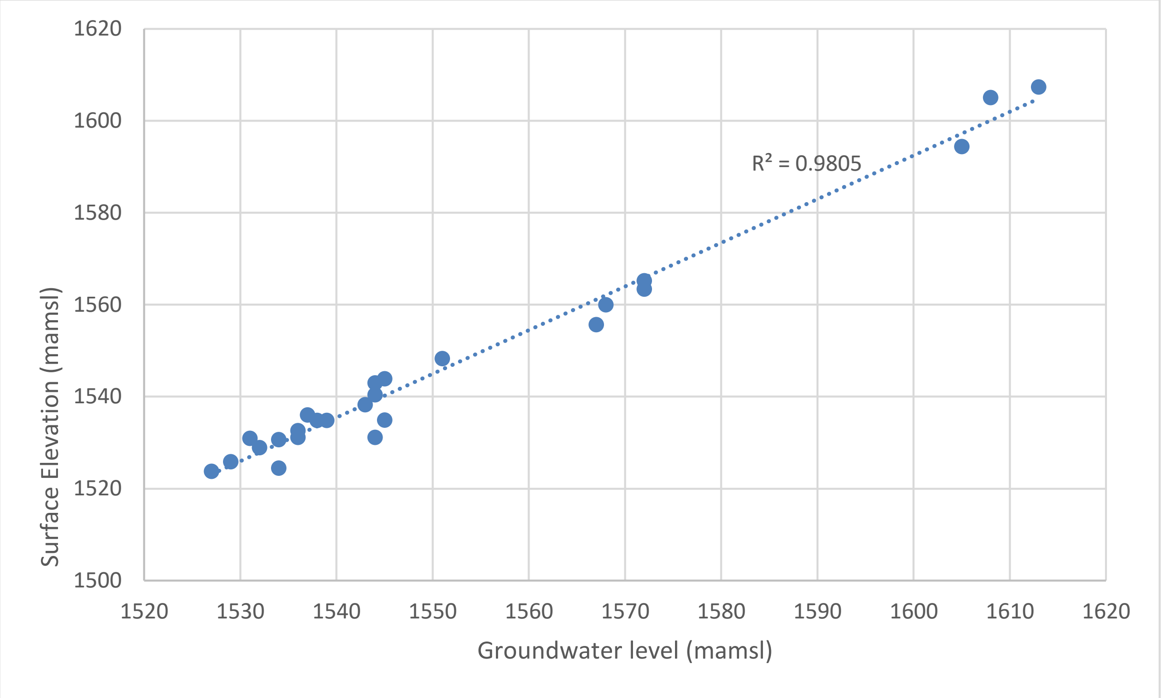


Figure 8-12: Bayesian Correlation – NCC and Roodekop Area

However, for Middeldrift the Bayesian correlation cannot be directly applied. Due to the current, surrounding mining activities, groundwater flow is expected to be mainly towards the surrounding underground mine voids, depending on active/inactive mining, mining depth and void flood level. Groundwater levels within the Project area are shallowest near the Steenkoolspruit, which acts as a source and locally recharges the aquifer.

8.5.5 Groundwater Quality

8.5.5.1 Historical Data

Water quality in and around the Project area was obtained from available monitoring data for the period October 2014 to September 2015 for the hydrogeological study for the proposed extension of the Roodekop mining area, only the boreholes in and around the Project area were considered. For locations that did not form part of the monitoring network, groundwater quality is defined by samples collected during previous hydrocensus investigations by Digby Wells (2011) and GCS (2014). The locations are presented in Figure 8-7.

These guidelines are supplemented by domestic water quality range guidelines prepared by the then Department of Water Affairs and Forestry in 1996 and 1998. The guidelines are as follows:

- Class 0 – Ideal water quality. Water is suitable for many generations, no effects;
- Class 1 – Good water quality. Water is suitable for lifetime use, with rare cases of sub-clinical effects;

- Class 2 – Marginal water quality. Water may be used without health effects by the majority of individuals with the exception of sensitive individuals or after lifetime use;
- Class 3 – Poor water quality. Water poses a chronic health risk especially to babies, children and elderly individuals; and
- Class 4 – Unacceptable water quality. Severe acute health effects, even with short term use.

There was no chemistry data available for a spring and BH28 (both part of the hydrocensus as conducted by GCS in 2014) as well as RK16 (part of hydrocensus survey conducted by Digby Wells in 2011). The groundwater quality based on the most recent groundwater samples (as provided by the client) can be summarised as follows (refer to SRK 2016 for more details):

- Gw-MID 1 (2015), classified as Class 3 which is poor water quality due to elevated ammonia concentrations (4.7 mg/L);
- RK10D (2011) classified as Class 4 which is unacceptable water quality due to TDS (526 mg/L);
- RK10S (2011) classified as Class 4 which is unacceptable water quality due to pH (10); and
- RBH5 (2015); classified as Class 2 which is marginal water quality due to elevated nitrate concentrations (9.98 mg/L).

The background water quality within and around the project area was found unsuitable for drinking according to the DWS water standards. This does not pose a risk to the intended mining activities and related water uses, as a requirement for groundwater as a source of domestic use for on-site use has not been indicated to be part of the proposed activities.

8.5.5.2 Current Data

8.5.5.2.1 Hydrogeochemical Characterisation

The Piper (Figure 8-13) and Expanded Durov diagrams (Figure 8-14) are presented to discuss the hydrogeochemical characterisation of the monitoring locations. The Piper diagram is particularly useful in creating groundwater facies that groups groundwater of similar chemistry into one section. The expanded Durov diagram improves the Piper diagram by displaying important hydrochemical process, such as ion exchange, simple dissolution and mixing of waters of different qualities (Nadiri *et al.,* 2013).

The average sample distribution on the Piper diagram plot shows varied water signatures within the study area. The Trilinear diagram shows that calcium and magnesium are more dominant over the alkalis (sodium and potassium). In addition, some samples show permanent hardness dominated by sulphate and calcium/magnesium (NCCBH11). Most samples show temporary hardness dominated by bicarbonate. Most samples do not have a dominant cation; however, the dominant anion signatures are shared between bicarbonate and sulphate. Only two samples (BH6 and BH5) show chloride dominance. The samples dominated by sulphate as the dominant anion can be attributed to influence from acid rock drainage from the exposed coal. The samples dominated by the bicarbonate anion can be attributed to background water signature in the area, possibly from the interaction with the underlying dolomites. Generally, waters with bicarbonate are considered freshly recharged.

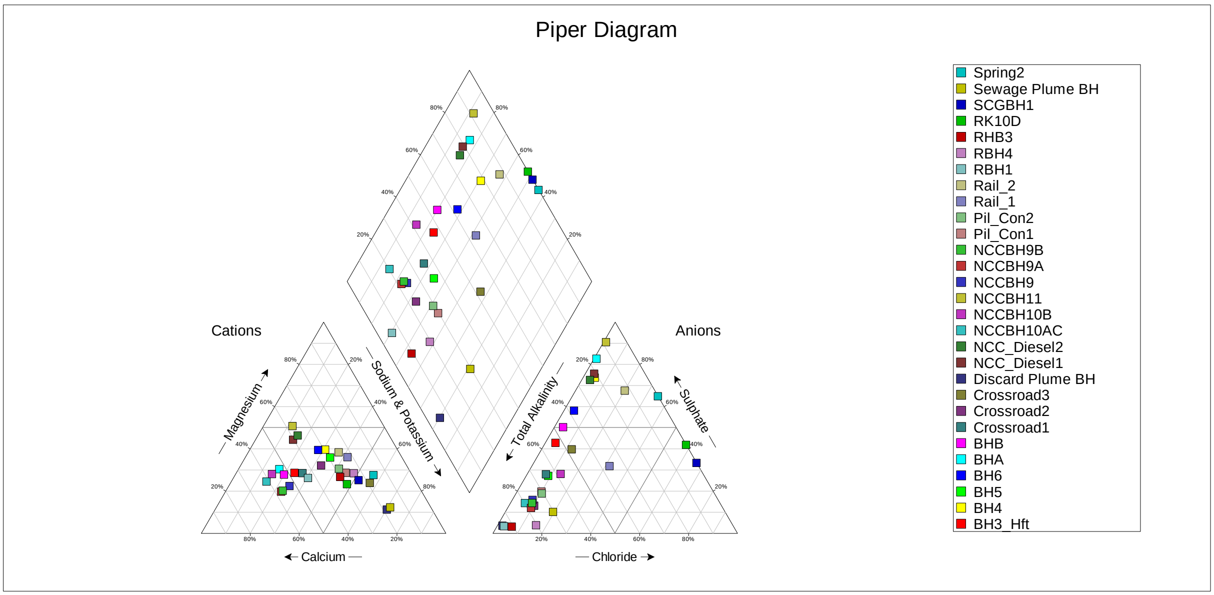


Figure 8-13: Piper Diagram for Monitoring Locations

The expanded Durov Diagram shows waters which plot in the following facies:

- Calcium/Magnesium-bicarbonate (Ca/Mg-HCO_3), these waters represent freshly recharged water into the aquifer;
- Magnesium-sulphate (Mg-SO_4), this signature is associated with some acid rock drainage influence on the groundwater; and
- Some samples plot within the sodium-bicarbonate (Na-HCO_3), sodium-sulphate (Na-SO_4), magnesium-chloride (Mg-Cl) and sodium-Chloride (Na-Cl). These signatures arise from the interaction between country rock and groundwater.

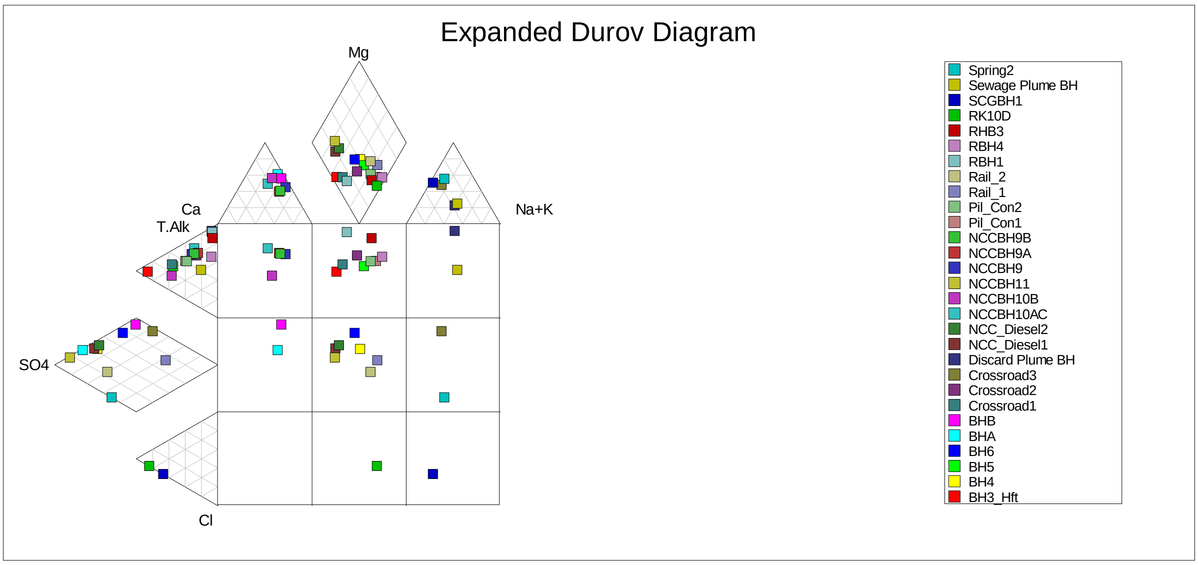


Figure 8-14: Expanded Durov Diagram for Monitoring Locations

8.5.5.2.2 Comparison with SAWQG: Drinking water

As the surrounding area is dominated by farming and farm houses the samples were compared to South African Water Quality Guidelines (SAWQG): Drinking Water (DWAF, 1996). Table 8-7 summarises the results from the monitoring points in 2020:

- The pH in most of the sampling points is within the SAWQG: Drinking waters ideal limit, except Spring 2 which was collected during the hydrocensus. The spring has a pH of 5.23;
- Generally, most analytes are within the ideal limit with a few exceedances above the unacceptable limit;
- BHA, BHB, BH4, BH6, NCC_Diesel 1, NCC_Diesel 2 and NCCBH11 are amongst the relatively most contaminated sampling points, showing exceedances above the unacceptable limit in multiple analytes such as electrical conductivity, total dissolved solids, calcium magnesium and sulphate; and
- Arsenic, cadmium, chromium, lead, zinc and zircon were not included in the table as most of the samples were not assessed for these analytes.

Table 8-7: Monitoring Borehole Samples Benchmarked Against the SAWQG: Drinking Water Standards

Sample ID	Date	pH	EC mS/m	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	Al mg/L	Fe mg/L	Mn mg/L
Ideal		6	70	450	32	30	100	50	100	200	1	0.15	0.1	0.05
Acceptable		9	150	1000	80	50	200	100	200	400	1.5	0.5	0.3	0.1
Unacceptable		<6 or >9	>150	>1000	>80	>50	>200	>100	>200	>400	>1.5	>0.5	>0.3	>0.1
RBH1	2021/03/01	7.6	27.4	138.5	23.0	8.4	17.3	2.7	3.2	4.2	<0.09	<0.01	0.10	0.05
RHB3	2021/03/01	7.1	11.6	55.0	5.9	3.2	8.1	3.1	2.5	1.5	0.35	<0.01	<0.01	0.07
RBH4	2021/03/01	9.2	13.2	68.7	5.0	3.7	7.9	6.8	3.8	1.2	0.11	<0.01	0.12	<0.01
NCC_Diesel1	2020/03/26	6.5	140.0	969.6	131.0	81.4	50.3	4.4	22.1	573.0	0.1	<0.01	0.09	0.35
NCC_Diesel2	2020/03/26	6.6	103.0	650.9	82.4	58.6	42.2	2.3	17.9	348.0	0.12	<0.01	0.24	1.25
NCCBH11	2020/03/26	6.2	227.0	2087.0	228.0	207.0	76.3	15.7	15.1	1444.0	1.84	<0.01	10.20	12.1
NCCBH9	2020/03/26	7.3	40.1	225.7	38.9	9.9	23.9	1.6	14.5	33.6	0.11	<0.01	0.02	0.02
Crossroad1	2020/03/26	7.5	35.3	196.2	31.3	12.2	17.7	4.2	11.1	49.3	0.76	<0.01	0.01	0.41
Crossroad2	2020/03/26	7.4	19.3	107.4	14.8	6.7	13.7	3.0	8.4	14.7	0.29	0.01	0.03	<0.01
Crossroad3	2020/03/26	7.1	21.7	101.8	3.3	3.4	25.5	0.9	9.7	44.9	0.24	<0.01	<0.01	0.02
Pil_Con1	2020/03/26	8.7	16.6	79.0	10.3	5.8	11.4	2.0	8.1	2.0	0.19	<0.01	0.10	<0.01
Pil_Con2	2020/03/26	7.9	18.5	88.9	11.7	7.6	10.2	2.0	11.0	5.1	0.17	<0.01	0.28	0.01
BHB	2020/03/26	7.6	28.9	149.3	30.6	7.2	13.5	4.8	5.4	4.0	0.2	<0.01	<0.01	<0.01
NCCBH9A	2020/03/26	7.3	28.6	161.4	33.3	5.0	11.6	2.3	9.1	11.6	0.1	<0.01	<0.01	0.04
NCCBH9B	2020/03/26	7.3	25.6	141.3	28.9	5.5	8.1	2.1	8.7	7.9	0.09	<0.01	<0.01	0.03

Sample ID	Date	pH	EC mS/m	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	Al mg/L	Fe mg/L	Mn mg/L
Ideal		6	70	450	32	30	100	50	100	200	1	0.15	0.1	0.05
Acceptable		9	150	1000	80	50	200	100	200	400	1.5	0.5	0.3	0.1
Unacceptable		<6 or >9	>150	>1000	>80	>50	>200	>100	>200	>400	>1.5	>0.5	>0.3	>0.1
NCCBH10B	2020/03/26	7.5	69.3	307.3	54.0	17.0	12.5	17.4	20.0	69.1	<0.09	<0.01	0.02	0.11
Rail_1	2020/03/26	7.0	42.5	229.3	17.7	16.9	35.4	3.2	46.1	63.3	0.26	<0.01	0.30	0.03
Rail_2	2020/03/26	7.1	78.8	486.8	39.4	37.0	65.5	3.3	63.1	235.0	0.1	<0.01	<0.01	0.7
NCCBH10AC	2020/03/26	7.1	43.3	240.1	54.0	13.3	12.1	4.8	8.9	25.0	<0.09	<0.01	<0.01	<0.01
BH3_Hft	2020/03/26	8.1	51.8	313.7	52.1	18.7	26.0	3.3	8.1	119.0	0.11	<0.01	<0.01	<0.01
BH4	2020/03/26	7.6	147.0	950.8	91.8	75.2	104.0	6.9	31.3	540.0	0.21	<0.01	<0.01	<0.01
BH5	2020/03/26	7.7	94.0	568.5	61.6	44.2	77.2	5.6	32.5	174.0	0.36	<0.01	0.01	0.25
BH6	2020/03/26	7.7	135.0	875.5	99.3	69.5	84.3	5.6	22.7	421.0	0.2	<0.01	0.46	0.99
BH_Phase2	2020/03/26	7.9	57.6	353.9	56.0	20.9	32.3	3.6	11.8	146.0	0.24	<0.01	0.21	0.06
RBH 1	2020/06/05	7.7	19.6	95.6	16.3	6.2	10.7	2.7	11.5	7.2	<0.09	<0.01	<0.01	-
RBH 3	2020/06/05	7.3	12.6	52.2	5.6	2.9	8.1	2.6	2.8	-0.5	0.21	<0.01	<0.01	-
RBH 4	2020/06/05	7.4	12.7	75.7	5.5	3.6	8.6	6.9	6.5	-0.5	<0.09	<0.01	0.01	-
NCC_Diesel1	2020/06/29	7.1	145.0	1062.1	140.0	96.9	66.2	4.7	21.8	629.0	<0.09	<0.01	0.09	0.24
NCC_Diesel2	2020/06/29	7.1	122.0	890.5	113.0	84.9	57.0	2.7	20.8	517.0	<0.09	0.11	0.13	0.06
NCCBH11	2020/06/29	7.2	42.8	240.8	42.7	10.5	27.3	2.2	13.6	52.5	<0.09	<0.01	<0.01	<0.01
NCCBH9	2020/06/29	7.4	43.1	244.9	43.0	10.6	27.6	2.2	13.9	52.0	<0.09	<0.01	<0.01	<0.01

Sample ID	Date	pH	EC mS/m	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	Al mg/L	Fe mg/L	Mn mg/L
Ideal		6	70	450	32	30	100	50	100	200	1	0.15	0.1	0.05
Acceptable		9	150	1000	80	50	200	100	200	400	1.5	0.5	0.3	0.1
Unacceptable		<6 or >9	>150	>1000	>80	>50	>200	>100	>200	>400	>1.5	>0.5	>0.3	>0.1
Crossroad2	2020/06/29	7.5	18.3	90.3	10.4	5.8	14.4	3.0	7.0	5.2	0.22	0.02	0.01	<0.01
Crossroad3	2020/06/29	7.0	18.4	92.2	10.9	6.3	13.6	3.0	6.9	7.9	0.22	<0.01	0.09	<0.01
Pil_Con1	2020/06/29	7.7	21.0	98.0	11.9	7.7	12.8	2.9	10.8	7.2	<0.09	<0.01	0.28	0.02
Pil_Con2	2020/06/29	7.4	28.3	140.2	20.8	12.1	12.5	3.1	7.9	29.3	<0.09	<0.01	0.20	0.03
BHA	2020/06/29	7.0	351.0	3415.2	589.0	196.0	169.0	10.2	20.8	2286.0	1.41	<0.01	0.18	1.04
BHB	2020/06/29	7.1	205.0	1661.2	283.0	99.0	90.8	7.9	13.0	1058.0	0.21	<0.01	<0.01	0.64
NCCBH9B	2020/06/29	7.3	43.0	244.2	43.5	10.5	27.4	2.1	13.1	55.3	<0.09	<0.01	<0.01	<0.01
NCCBH10B	2020/06/29	7.4	80.2	426.9	64.5	17.8	8.3	12.2	40.0	35.8	<0.09	<0.01	0.03	0.1
Rail_1	2020/06/29	7.0	42.6	223.6	17.3	15.8	37.4	3.3	48.6	55.7	0.2	<0.01	0.05	0.08
Rail_2	2020/06/29	7.1	68.5	411.4	29.6	30.9	57.9	2.4	62.6	202.0	<0.09	<0.01	0.09	0.18
BH3_Hft	2020/06/29	7.7	56.3	344.1	55.0	19.3	35.8	3.8	13.6	130.0	0.1	<0.01	0.08	0.05
BH4	2020/06/29	7.7	56.2	340.7	55.1	19.3	36.1	3.8	14.3	129.0	0.1	-0.01	0.09	0.06
BH5	2020/06/29	7.8	55.7	338.0	55.0	18.9	35.5	3.7	13.7	127.0	<0.09	-0.01	0.10	0.06
BH6	2020/06/29	8.0	55.7	341.7	56.0	19.7	36.5	3.8	13.6	129.0	0.1	-0.01	0.13	0.06
BH_Phase2	2020/06/29	7.6	56.6	351.2	54.9	19.6	37.5	4.1	15.9	134.0	-0.09	-0.01	<0.01	0.04
NCC_Diesel1	2020/08/28	7.1	146.0	1055.5	140.0	94.2	62.0	4.8	52.1	598.9	<0.09	-0.01	<0.01	0.3

Sample ID	Date	pH	EC mS/m	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	Al mg/L	Fe mg/L	Mn mg/L
Ideal		6	70	450	32	30	100	50	100	200	1	0.15	0.1	0.05
Acceptable		9	150	1000	80	50	200	100	200	400	1.5	0.5	0.3	0.1
Unacceptable		<6 or >9	>150	>1000	>80	>50	>200	>100	>200	>400	>1.5	>0.5	>0.3	>0.1
NCC_Diesel2	2020/08/28	7.3	131.0	937.7	119.0	85.3	57.3	3.3	19.4	558.0	<0.09	-0.01	<0.01	0.03
NCCBH11	2020/08/28	7.8	42.5	213.3	38.9	11.1	20.8	2.5	10.1	29.6	0.09	-0.01	<0.01	0.01
NCCBH9	2020/08/28	7.9	40.4	217.9	39.2	11.1	21.8	2.4	10.4	24.5	<0.09	-0.01	<0.01	0.01
Crossroad2	2020/08/28	7.5	14.4	80.7	9.0	6.3	11.9	3.0	3.3	3.8	0.33	0.02	0.01	<0.01
Crossroad3	2020/08/28	7.4	17.3	90.5	11.0	6.3	13.2	3.0	8.1	3.9	0.35	0.06	0.03	<0.01
Pil_Con1	2020/08/28	7.7	30.7	163.0	23.7	14.8	10.5	3.4	6.6	37.4	<0.09	-0.01	<0.01	<0.01
Pil_Con2	2020/08/28	8.0	27.8	142.7	18.7	13.5	12.0	3.4	6.0	25.1	<0.09	<0.01	<0.01	<0.01
BHA	2020/08/28	7.4	34.6	188.6	24.4	12.1	23.9	8.0	7.5	13.9	0.11	0.06	0.73	0.16
BHB	2020/08/28	7.6	40.6	226.4	35.9	12.3	24.9	6.6	10.0	26.5	0.09	<0.01	0.13	0.04
NCCBH9A	2020/08/28	7.8	40.2	216.9	39.2	11.1	20.9	2.5	10.0	25.2	<0.09	<0.01	<0.01	0.01
NCCBH9B	2020/08/28	7.7	40.6	215.8	40.0	11.1	20.7	2.5	10.2	26.6	<0.09	<0.01	<0.01	0.03
Rail_1	2020/08/28	7.3	42.4	207.2	16.0	16.1	33.9	3.4	46.5	59.4	0.25	<0.01	0.08	0.12
Rail_2	2020/08/28	7.4	63.0	383.3	24.6	28.3	58.8	2.6	54.7	184.0	<0.09	<0.01	<0.01	0.58
BH3_Hft	2020/08/28	8.2	49.9	278.8	43.2	17.0	26.9	3.6	6.8	98.4	0.1	<0.01	0.02	<0.01
BH4	2020/08/28	7.8	155.0	1077.3	101.0	85.8	127.0	7.2	30.3	622.0	0.2	<0.01	0.02	<0.01
BH5	2020/08/28	7.8	104.0	602.1	60.2	50.0	88.7	6.0	38.3	146.0	0.36	<0.01	<0.01	0.44

Sample ID	Date	pH	EC mS/m	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	Al mg/L	Fe mg/L	Mn mg/L
Ideal		6	70	450	32	30	100	50	100	200	1	0.15	0.1	0.05
Acceptable		9	150	1000	80	50	200	100	200	400	1.5	0.5	0.3	0.1
Unacceptable		<6 or >9	>150	>1000	>80	>50	>200	>100	>200	>400	>1.5	>0.5	>0.3	>0.1
BH6	2020/08/28	7.8	155.0	1077.7	102.0	86.3	127.0	7.1	31.0	637.0	0.21	<0.01	0.03	<0.01
BH_Phase2	2020/08/28	7.9	57.0	324.1	46.4	19.9	35.3	4.2	13.6	121.0	0.32	<0.01	0.01	0.12
Sewage Plume BH	2020/08/28	8.2	20.1	98.0	6.1	2.1	31.4	2.2	1.7	-0.5	1.71	<0.01	<0.01	<0.01
Discard Plume BH	2020/08/28	8.1	20.8	106.4	7.0	2.4	31.7	2.1	1.8	2.7	1.62	<0.01	<0.01	<0.01
RBH 1	2020/12/02	7.7	20.0	92.8	16.0	6.1	10.6	2.2	10.1	2.0	0.12	<0.01	<0.01	0.13
RBH 3	2020/12/02	7.0	13.6	63.4	6.4	4.0	6.5	4.4	1.9	1.8	0.53	<0.01	0.17	0.13
RBH 4	2020/12/02	7.0	11.9	63.9	4.9	3.3	6.5	6.5	3.8	-0.5	0.22	<0.01	0.13	<0.01
NCC_Diesel1	2020/12/02	6.6	148.0	1155.2	151.0	98.6	66.2	4.5	18.4	709.0	-	<0.01	-1.00	-
NCC_Diesel2	2020/12/02	6.7	135.0	979.4	119.0	94.1	59.5	2.5	18.4	580.0	-	<0.01	-1.00	-
NCCBH11	2020/12/02	6.7	232.0	2080.1	241.0	198.0	86.1	16.2	14.2	1426.0	-	<0.01	-1.00	-
NCCBH9	2020/12/02	7.2	40.0	212.6	43.6	10.8	19.4	2.0	9.3	19.1	-	<0.01	-1.00	-
Crossroad2	2020/12/02	7.2	18.8	92.0	9.0	6.5	17.7	2.7	6.1	5.5	-	<0.01	<0.01	-
Crossroad3	2020/12/02	7.1	19.6	92.6	10.9	7.4	13.8	2.7	5.9	5.7	-	<0.01	<0.01	-
Pil_Con1	2020/12/02	8.8	57.2	330.4	2.4	2.5	121.0	0.8	20.8	70.6	-	<0.01	<0.01	-

Sample ID	Date	pH	EC mS/m	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO4 mg/L	F mg/L	Al mg/L	Fe mg/L	Mn mg/L
Ideal		6	70	450	32	30	100	50	100	200	1	0.15	0.1	0.05
Acceptable		9	150	1000	80	50	200	100	200	400	1.5	0.5	0.3	0.1
Unacceptable		<6 or >9	>150	>1000	>80	>50	>200	>100	>200	>400	>1.5	>0.5	>0.3	>0.1
Pil_Con2	2020/12/02	7.8	29.8	159.7	18.3	10.2	27.1	2.8	8.6	26.6	-	<0.01	<0.01	-
BHA	2020/12/02	7.3	28.0	135.6	22.8	8.2	16.3	3.7	4.4	3.4	-	<0.01	<0.01	-
BHB	2020/12/02	8.0	31.4	152.7	23.7	9.6	18.8	4.4	4.8	3.0	-	<0.01	<0.01	-
NCCBH9A	2020/12/02	7.5	41.9	232.9	45.2	12.1	20.0	2.2	13.3	29.7	-	<0.01	<0.01	-
NCCBH9B	2020/12/02	7.5	40.5	213.9	43.6	10.8	19.7	2.1	9.5	20.1	-	<0.01	<0.01	-
Rail_1	2020/12/02	6.5	42.5	223.0	18.0	16.5	35.1	3.0	43.8	56.8	-	<0.01	<0.01	-
Rail_2	2020/12/02	6.6	73.2	467.4	39.0	33.0	62.0	3.1	47.2	262.0	-	<0.01	<0.01	-
BH3_Hft	2020/12/02	7.9	48.0	289.1	45.5	18.2	27.1	3.2	7.6	101.0	-	<0.01	<0.01	-
BH4	2020/12/02	7.5	162.0	1180.7	103.0	95.1	125.0	7.0	29.8	721.0	-	<0.01	<0.01	-
BH5	2020/12/02	7.3	248.0	1548.6	156.5	132.0	238.0	10.2	111.0	285.0	-	<0.01	<0.01	-
BH6	2020/12/02	7.5	163.0	1092.2	120.0	97.0	120.0	6.8	27.1	485.0	-	<0.01	<0.01	-
BH_Phase2	2020/12/02	7.9	53.7	327.4	48.8	19.1	34.3	3.6	12.8	118.0	-	<0.01	<0.01	-
Sewage Plume BH	2020/12/02	8.1	17.6	92.7	6.1	3.0	26.1	1.5	-0.5	2.6	-	0.79	<0.01	-
Discard Plume BH	2020/12/02	8.1	17.6	78.6	4.5	1.8	23.7	1.5	-0.5	-0.5	-	0.85	<0.01	-

8.5.5.2.3 Groundwater Quality Trend Analysis Compared To The SAWQG Guidelines

The water quality trends from the beginning of 2020 to the beginning of 2021 are presented in Figure 8-15 to Figure 8-25. The findings are summarised below:

- All samples were compliant with the SAWQG for drinking water in 2020 with regards to pH. NCCBH11 was the only exception in the beginning of 2020. In 2021, Spring 2 and RBH2 were not within the compliant range for pH;
- Most samples were within the ideal limit with regards to electrical conductivity, total dissolved solids and calcium standard when compared to SAWQG for drinking water except NCCBH11, BHA and BH5; and
- Generally, most of the samples plot within the SAWQG for drinking water. NCCBH11 consistently exceeds the limits in most of the analytes.

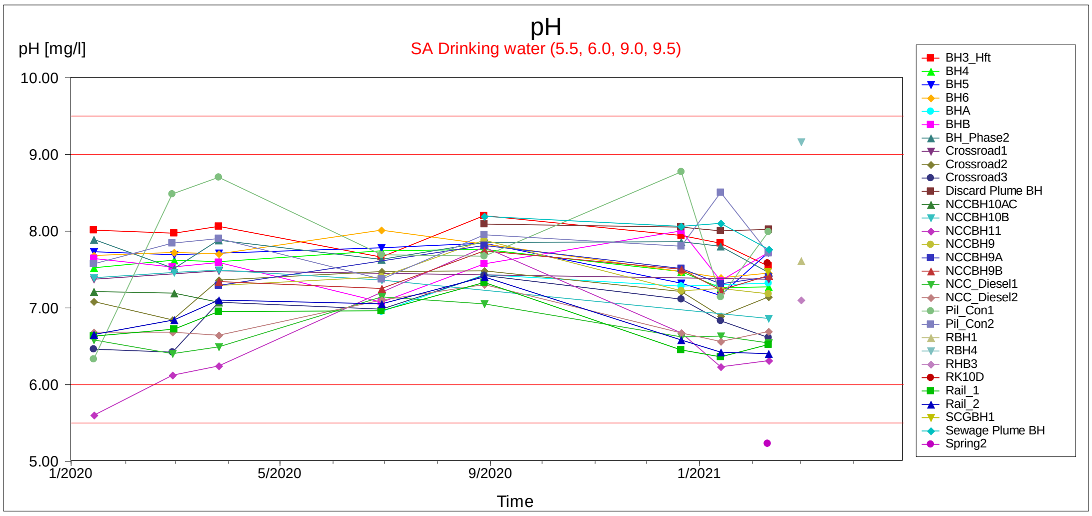


Figure 8-15: pH Trend

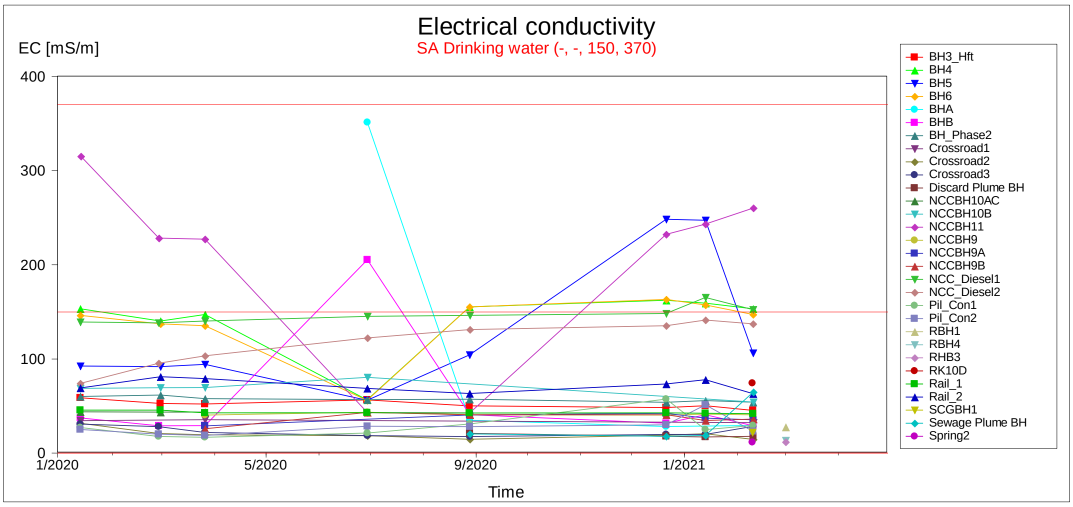


Figure 8-16: Electrical Conductivity Trend

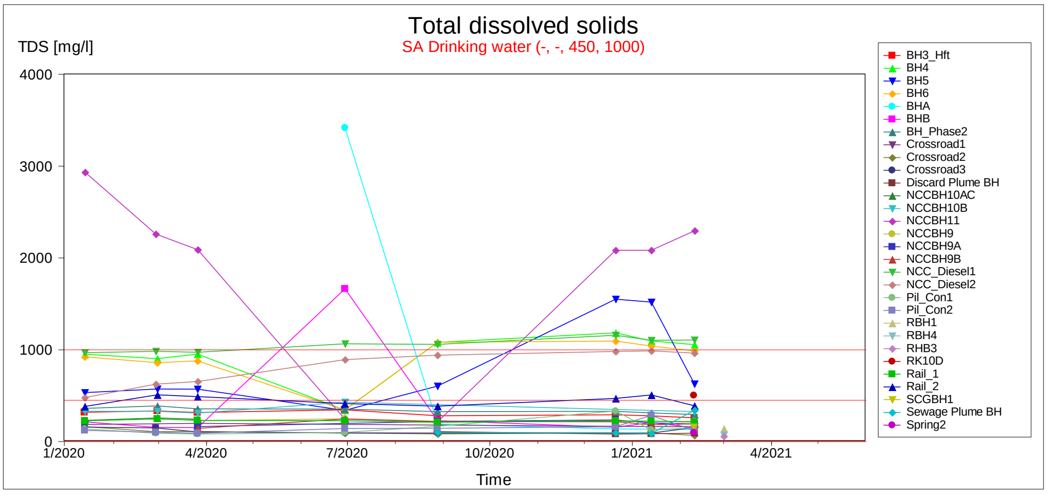


Figure 8-17: Total Dissolved Solids Trend

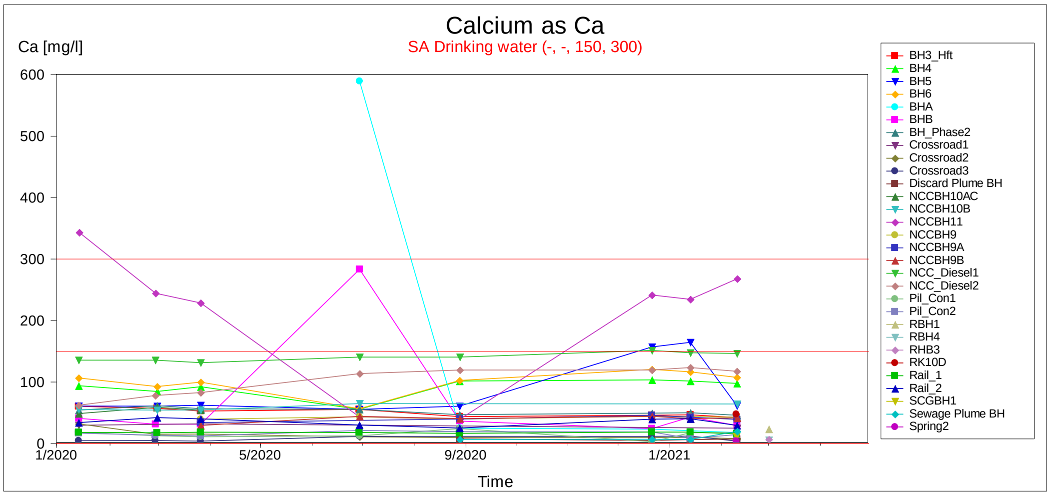


Figure 8-18: Calcium Trend

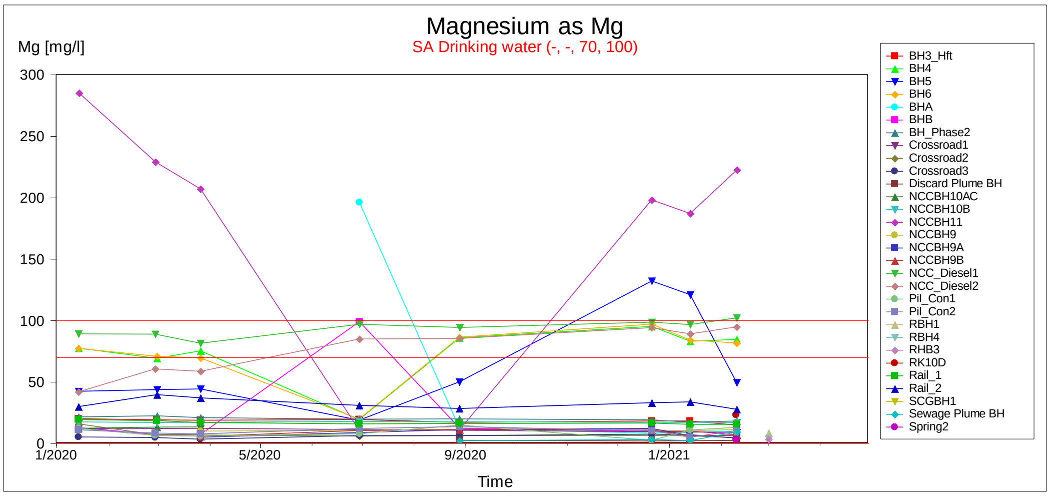


Figure 8-19: Magnesium Trend

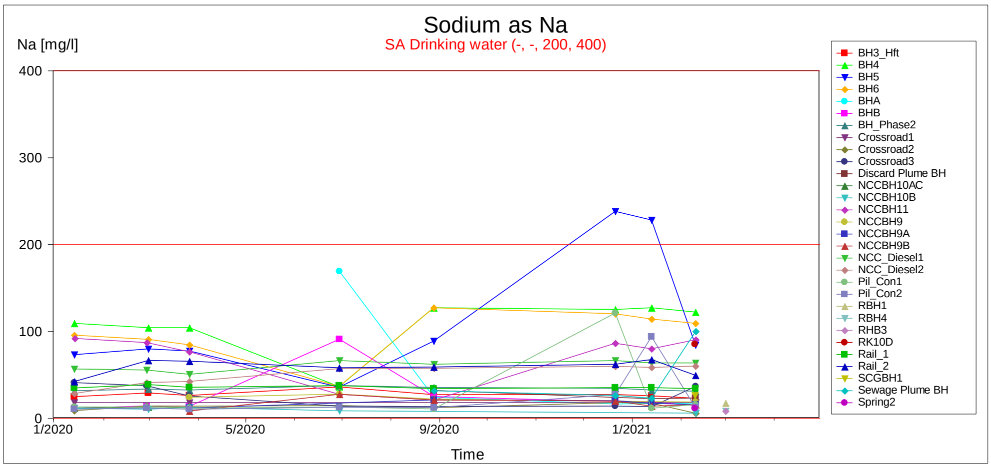


Figure 8-20: Sodium Trend

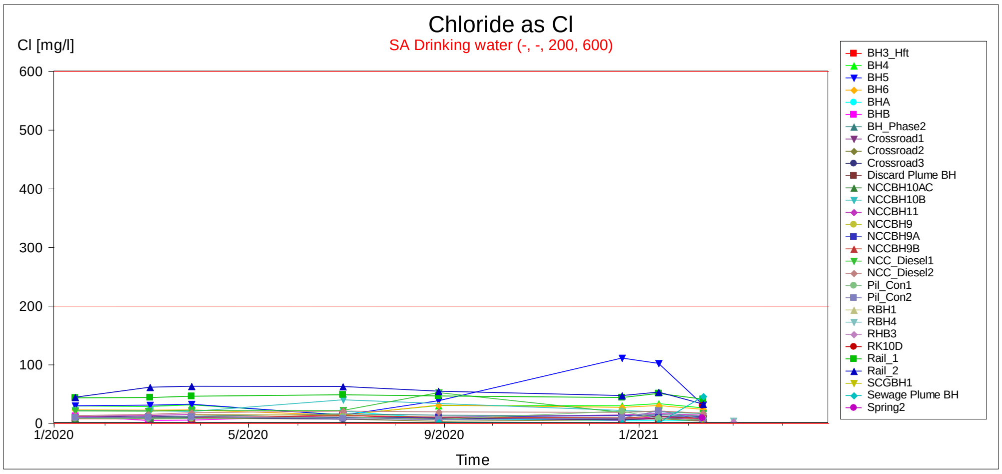


Figure 8-21: Chloride Trend

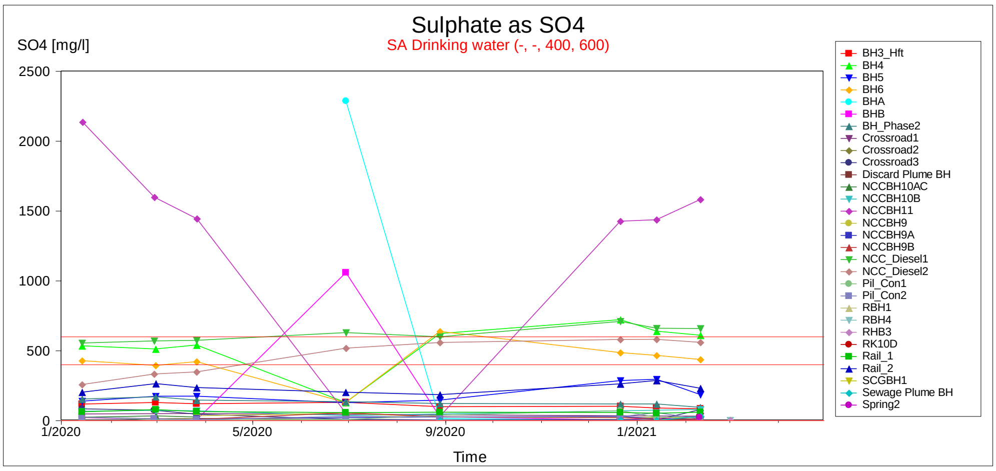


Figure 8-22: Sulphate Trend

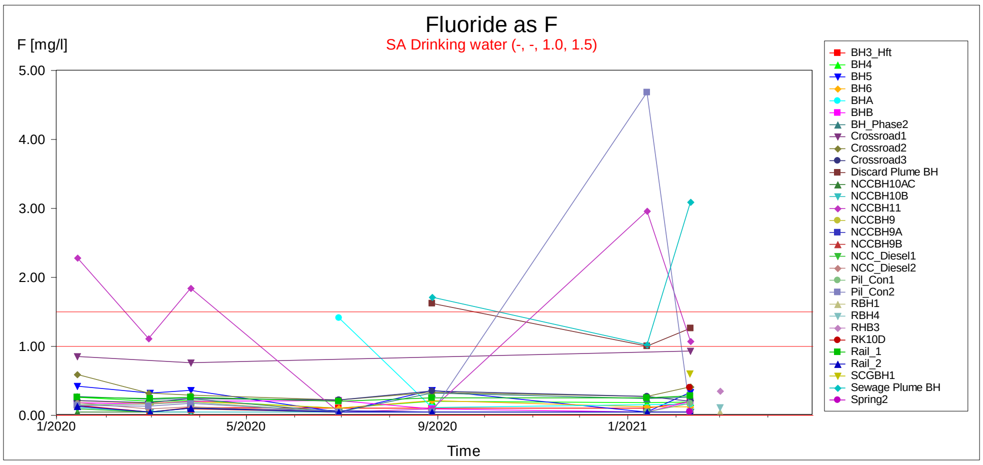


Figure 8-23: Fluoride Trend

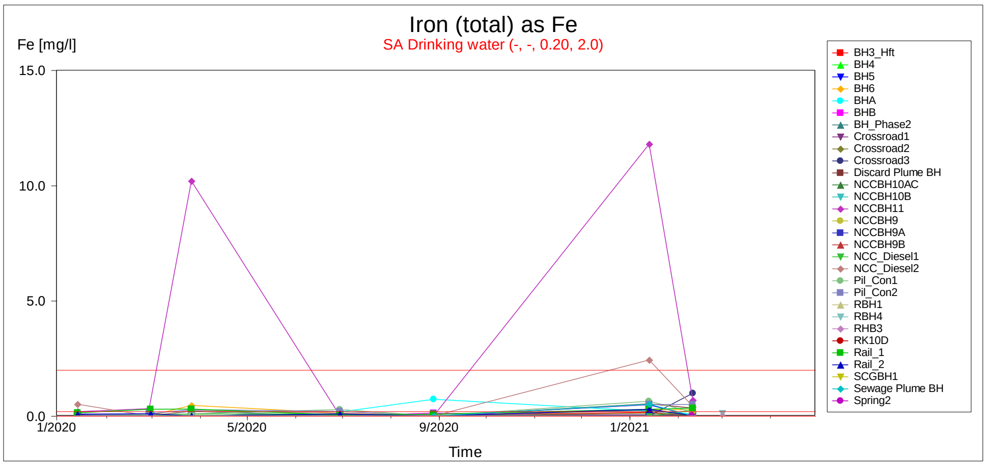


Figure 8-24: Iron Trend

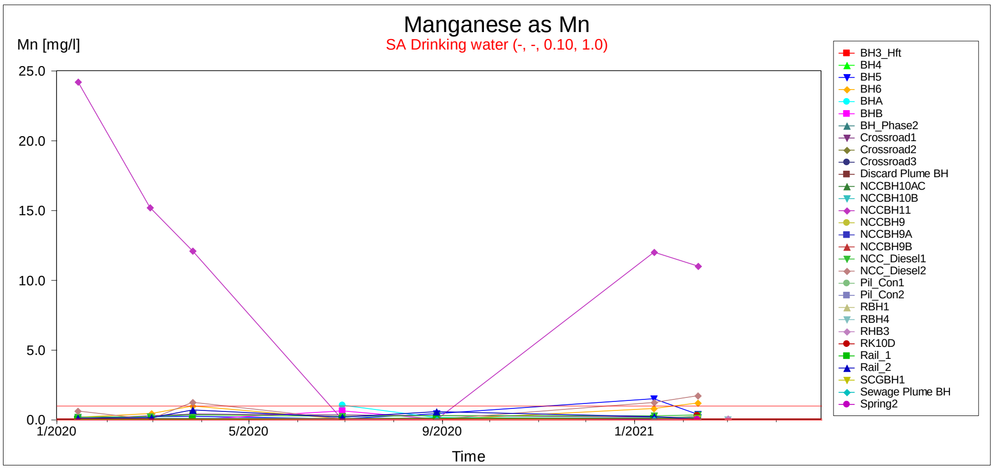


Figure 8-25: Magnesium Trend

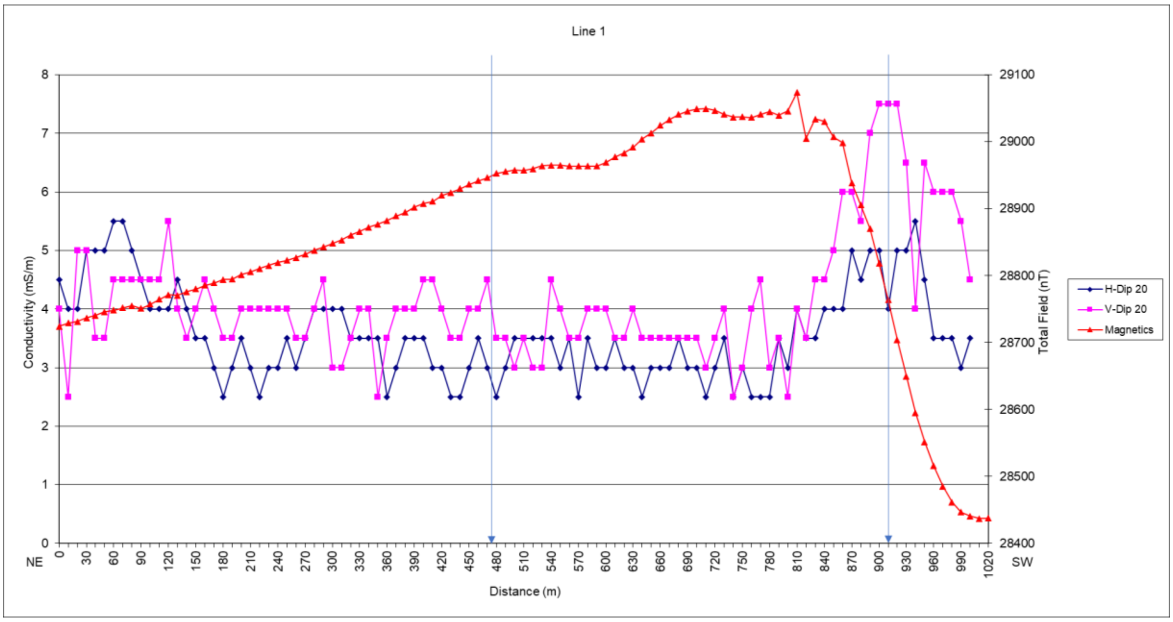
8.6 Geophysical Survey

During a geophysical survey, four lines were surveyed close to the proposed open pit at Middeldrift (Figure 8-27). The aim of the survey was to characterise the ground conditions in the vicinity of the proposed open pit, to indicate potential geological structures or preferential flow paths for groundwater and to generate targets for monitoring boreholes. The electromagnetic and magnetic survey methods were used.

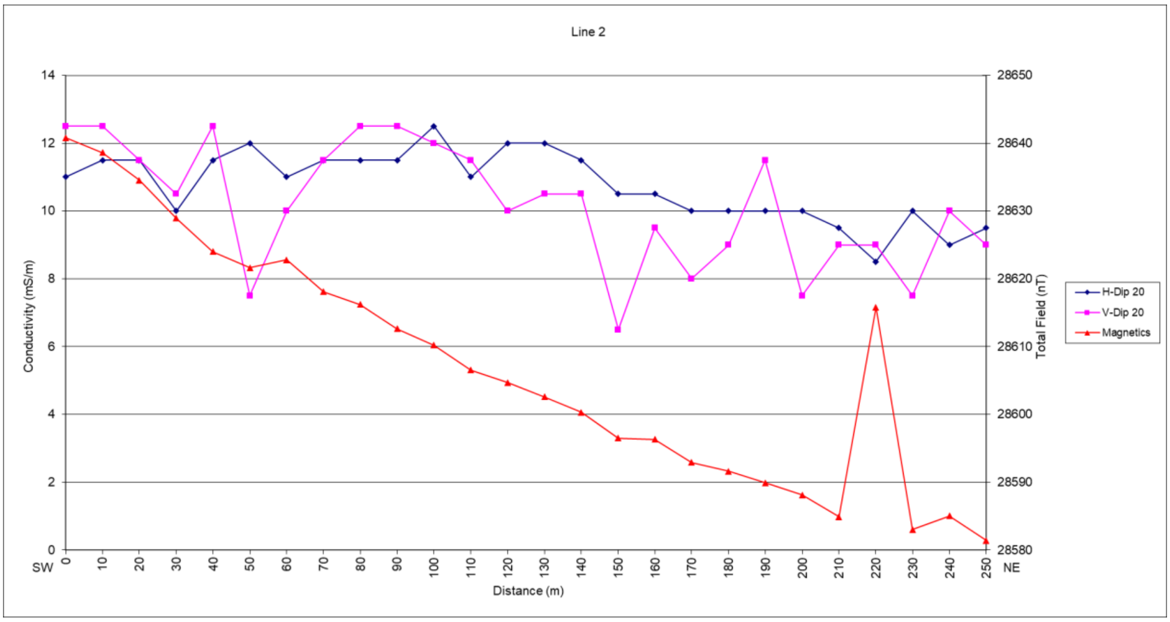
Electro Magnetic (EM) conductivity surveys measure ground conductivity by electromagnetic induction. The electromagnetic system used for the site investigation was the EM 34-3 ground conductivity meters. The system consists of a transmitter and receiver coil spaced at a fixed configuration. Magnetic surveys record spatial variation in the earth's magnetic field, i.e. orientation and strength of the field. The instrument used in magnetic surveying is a magnetometer, in this case a Geomatrix.

The lines were interpreted based on anomalies in the EM and magnetic data in conjunction with lithological units and geological structures, as indicated on the regional geological map. The results are shown in Figure 8-26. Four drill targets were identified (Figure 8-26). Targets 3 and 4 were moved westwards and south-eastwards, respectively, due to access constraints. Both targets were eventually chosen based on site access and local farm roads.

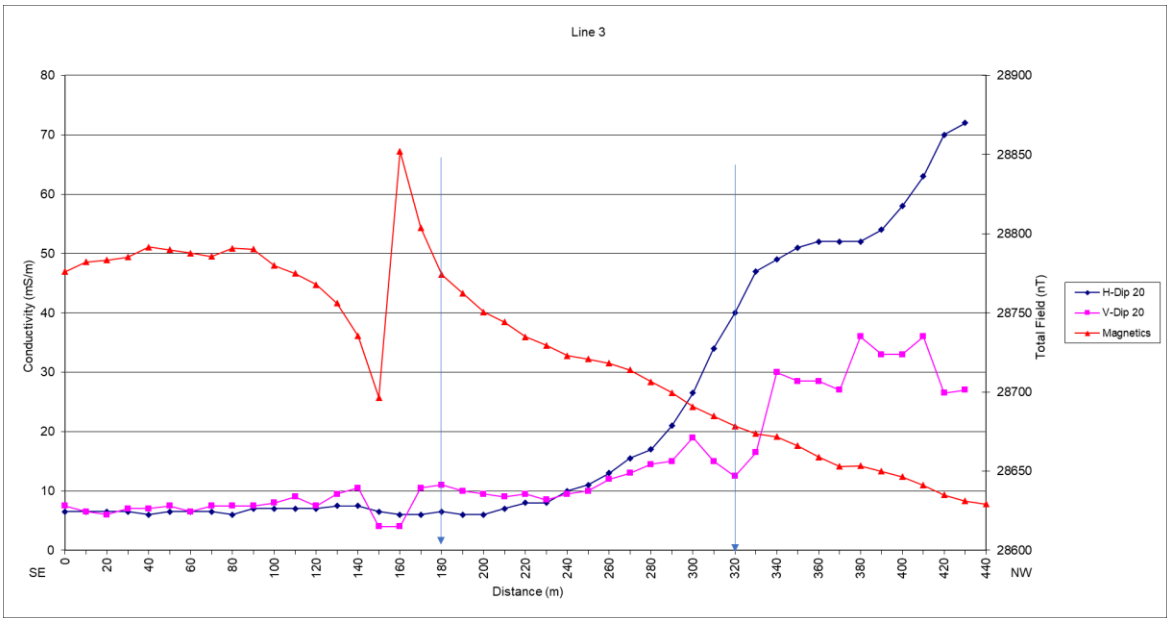
Line 1


Line 1
Conductivity (mS/m)
Total Field (nT)
Distance (m)
NE
SW
H-Dip 20
V-Dip 20
Magnetics

Line 2


Line 2
Conductivity (mS/m)
Total Field (nT)
Distance (m)
SW
NE
H-Dip 20
V-Dip 20
Magnetics

Line 3



Line 4

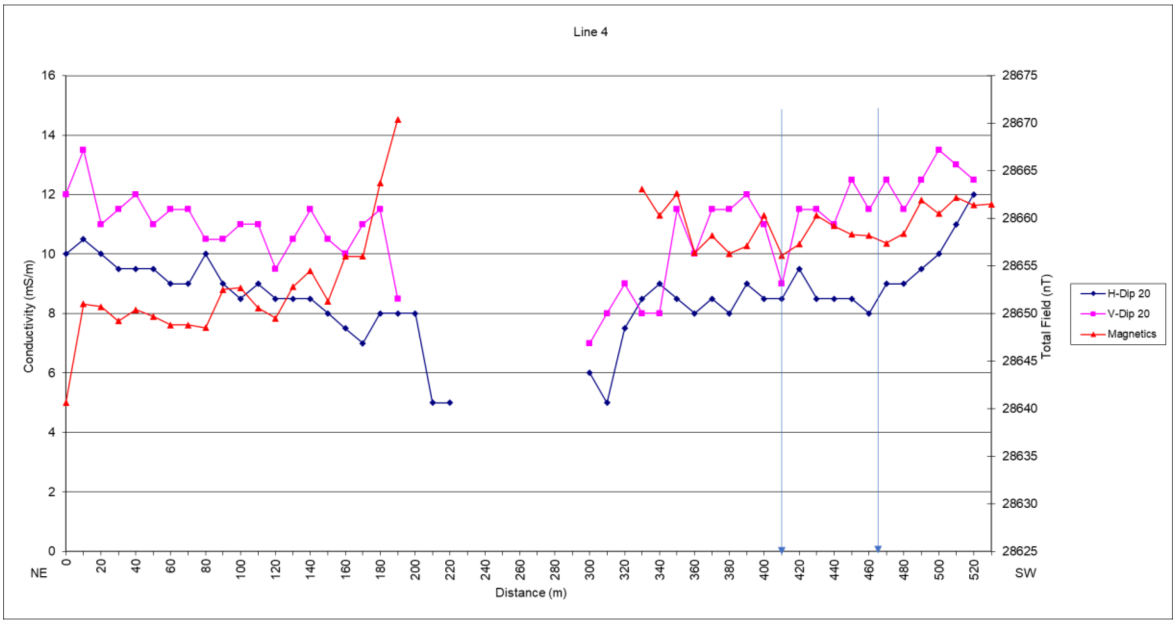


Figure 8-26. Geophysical survey line results

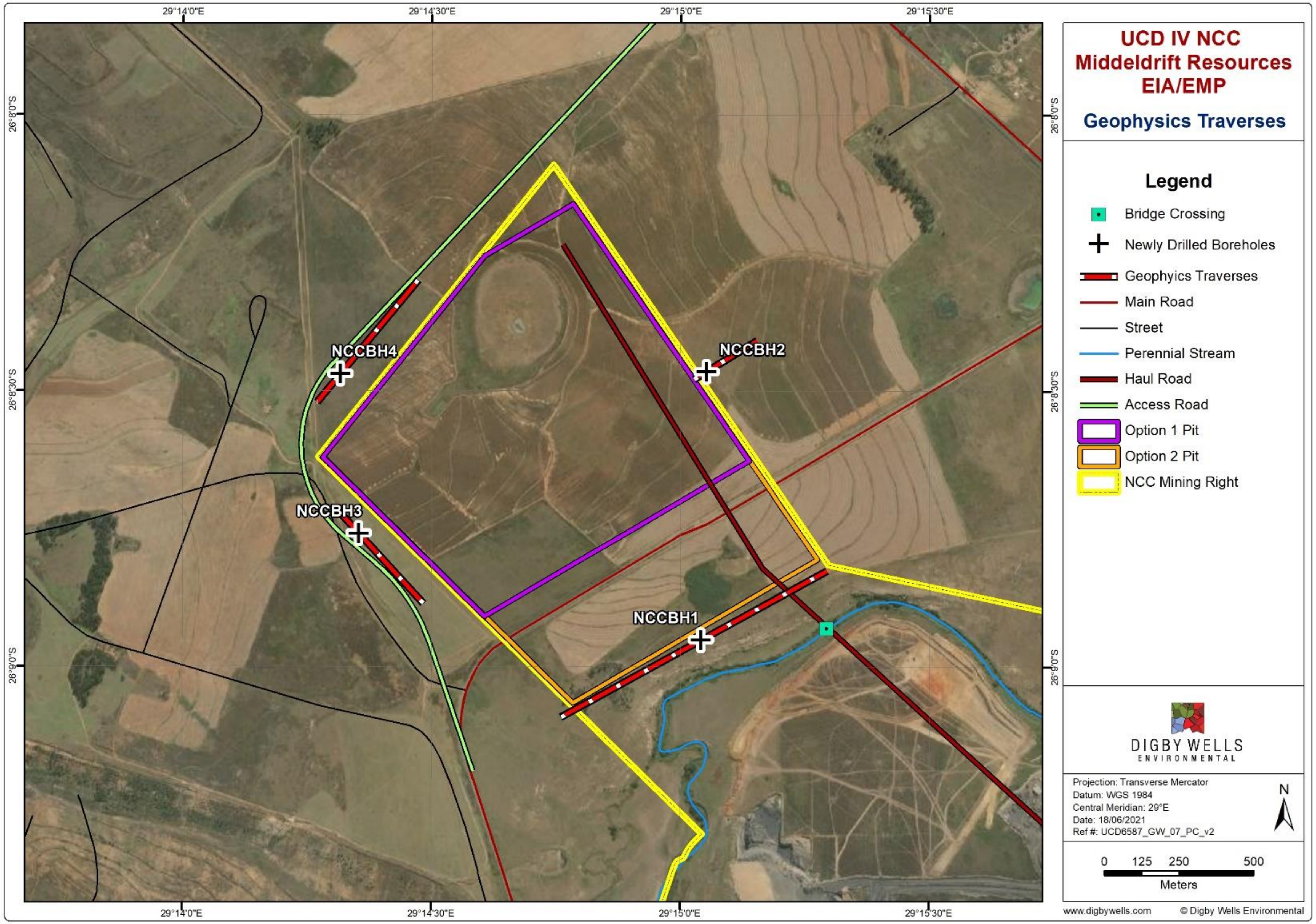


Figure 8-27: Geophysical survey lines and derived drill targets

8.7 Borehole Drilling

The drilling of four monitoring boreholes was carried out in April 2021. The boreholes were drilled to depths between 43 and 52 mbgl. The borehole construction for all four holes was as follows:

- Percussion drilling at 8 inch open hole diameter;
- Installation of 7 inch ID temporary mild steel casing to prevent hole collapse;
- Continue percussion drilling at 7 inch open hole diameter;
- Installation of 5.5 inch uPVC casing (85% slotted / 15% plain casing); and
- Backfill of the annulus with a gravel pack at the height of the slotted casing, bentonite seal on top of the gravel pack and backfill with arisings.

The boreholes were drilled for the following purposes:

- Description of the encountered lithologies;
- Identification of water strikes/seepages;
- Collection of samples for geochemical testing;
- Collection of groundwater samples; and
- Measurement of groundwater levels.

The drilling method used in this programme was rotary-air percussion. The drilling technique was selected for hydrogeological characterisation of the encountered geology, as identification of groundwater inflow and associated air-lift yield can be undertaken during the drilling process. The following information was recorded during the drilling at each drill target:

- Geological information:
  - Lithology – 1 m intervals;
  - Interpreted structure; and
  - Depth and degree of weathering.
- Hydrogeological information:
  - Depth of groundwater strikes and/or seepage; and
  - Air-lift yield.
- Other information:
  - Penetration rate (indication of weathered/competent rock) – where recorded.

The drill locations are shown on Figure 8-27 and the borehole logs are shown in Appendix A.

9 Geochemistry

9.1 Previous Studies

A geochemical assessment was conducted material from NCC in 2012 (GCS, 2014). The mined material for the Project area is expected to have similar mineralogical content. The mineralogical content was identified as:

- Quartz – minor to major mineral in the coal, discard and slurry samples;
- Kaolinite – dominant mineral in the coal, discard and slurry samples;
- Mica (muscovite) and K-Feldspar – minor minerals in some of the discard and slurry samples;
- Calcite/aragonite and dolomite – trace to minor minerals in all samples;
- Rutile and anatase and Ti-oxides;
- Gypsum – minor mineral in slurry samples; and
- Pyrite – minor mineral in all samples.

The results from the Acid-Base-Accounting (ABA) and leach tests were used to determine expected non-compliance in terms of groundwater quality that may occur in drainage from the mine. The following comments relate to the mine water quality, separated for several activities.

9.1.1 Open Pits

Not enough neutralisation minerals are available in the carbonaceous material to neutralise the acidity produced by pyrite oxidation over the medium- to long-term. No testing was performed on the clastic rock overburden of the open cast pits in order to determine its geochemical character. It is not foreseen that significant elevation in metals will occur at near-neutral conditions. After acidification, elevated Al, Fe and Mn concentrations will occur. Other metals like Cr and Ni (as identified through peroxide extraction) may also leach out at elevated concentrations; however, significant non-compliance of these metals are unlikely to occur under field conditions.

9.1.2 Discard And Slurry Disposal

Not enough neutralisation minerals are available in the discard material to neutralise the acidity produced by pyrite oxidation over the medium- to long-term. Discard on surface will definitely generate acid drainage over the long-term. If discard is co-disposed in pits, the neutralisation potential of the waste rock must be determined.

The slurry seems to have a much lower potential to generate acid-mine drainage than the raw coal or the coarse discard; and therefore, slurry pumped to the underground will probably have no detrimental effect on the underground mine water quality over the long-term.

Slurry disposal underground may contribute to the exclusion of oxygen from the underground, thereby minimising acid-mine drainage generation from the remaining coal underground.

9.1.3 Underground Mine (Diepspruit)

Not enough neutralisation minerals are available in the coal to neutralise the acidity produced by pyrite oxidation.

However, if the underground mine can be fully flooded post-closure, this would reduce the ingress of oxygen and the subsequent oxidation of pyrite and acid-mine drainage generation.

In addition, if shafts and exploration boreholes would be sealed-off after closure, very little oxygen ingress would occur before flooding.

As discussed above, slurry disposal into the underground may also contribute to the exclusion of oxygen from the underground.

Overall, the potential for acid-mine drainage in the underground mine will be low, but the actual impact will depend on several factors including potential for oxygen ingress, oxygen consumption rate in the underground, flooding rates, final percentage of void flooding and locations of slurry disposal.

9.2 Current study

The GCS environmental geochemistry study conducted in 2014 focused on the discard/slurry and coal and a gap was identified in the lack of waste rock characterisation. The geochemical study focused on the characterisation of the waste rock material. A total of eight samples were collected, namely two overburden and six inter-burden waste rock samples. A summary of the results is given below.

9.2.1 Mineralogy

The mineralogy of the samples indicates no acid-forming minerals in the overburden and inter-burden. The acid neutralising mineral dolomite that is dissolving is detected in overburden sample above No. 4 upper seam and inter-burden samples between No. 4 upper and lower seams; and between No. 2 upper seam and No. 1 Seam. Other acid neutralising minerals with weathering rates ranging from very fast to very slow were detected. The minerals include Goethite, Diopside, Chlorite, Biotite, Muscovite, Plagioclase, Kaolinite, Smectite and Microcline.

9.2.2 Acid Generation Potential

The ABA test results indicate that the overburden samples are 100% Non-Acid Forming (NAF); and the inter-burden samples are 87% NAF, while approximately 13% of the inter-burden results were inconclusive. Relative to the slurry and discard samples from the GCS study are 100% Potentially Acid Forming (PAF), while the coal samples were 80% PAF and approximately 20% of the coal results were inconclusive.

9.2.3 Metal Leaching

The Metal Leaching potential of the waste rock samples were assessed against the Water Use License (WUL) limits for NCC and the background water quality from the hydrocensus study. The following was indicated:

- The pH of both the overburden (pH 6.3 - 6.5) and the inter-burden (pH 6.1 - 7.9) leachates are neutral,
- Arsenic, copper, manganese, molybdenum, nickel, and selenium exceed the baseline groundwater levels in both the overburden and the inter-burden material. There are no WUL limits for these metals/metalloids,
- Sulphate (19 mg/l) in the overburden leachate exceeds the baseline groundwater levels (5.2 mg/l) in the overburden material, but is within the WUL limits (600 mg/l),
- Nitrate as N (1.2 - 2.2 mg/l) exceeds the baseline groundwater levels (0.1 mg/l) but is within the WUL limits (20 mg/l); and
- The discard/slurry and coal hydrogen peroxide leachate quality assessed against the WUL limited and baseline groundwater quality indicated that boron, chromium, copper, electrical conductivity, manganese, nitrate, sulphate, total dissolved solids and zinc. These parameters should be included in the surface and groundwater quality monitoring programme for the mine.

9.2.4 Waste Classification

The study classified the overburden and inter-burden materials against the Norms and Standards for the Assessment of Waste for Landfill Disposal (GN R635 of 23 August 2013) and the Norms and Standards for Disposal of Waste to Landfills (GN R636 of 23 August 2013).

Total Concentrations (TC) of arsenic, barium, chromium and copper in the overburden and boron, chromium and copper in inter-burden exceeded the TCT0 threshold limit. The Leachable Concentration Threshold (LCT) of arsenic in the overburden and arsenic and selenium in the inter-burden exceeded the LCT0 threshold limit. The other metal ions are relatively immobile under the neutral pH and are not mobilised into the leachate with their Leachable Concentration (LC) below the LCT0 limit.

The overburden and the inter-burden are assessed to be Type 3 waste, LC ≤ LCT0 and TC ≤ TCT0. Applying GN R636 of 2013, the strict interpretation of this assessment is that the disposal of the overburden and inter-burden would require a barrier consistent with a Class C barrier system indicated in the figure below.

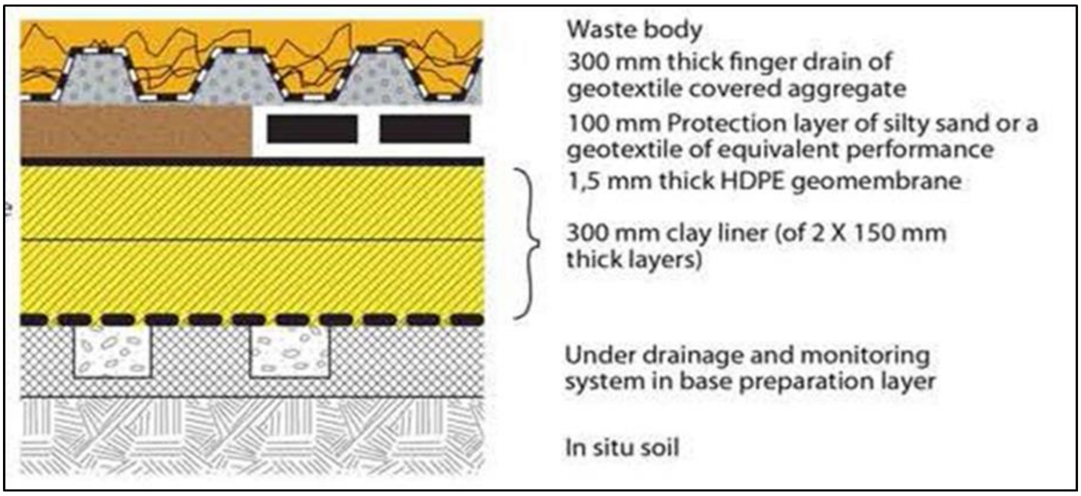


Figure 9-1: Illustration of a Class C barrier requirements for inter-burden and coal (GN R636 of 23 August 2013)

The classification and assessment of the spoils indicated that the overburden and the inter-burden require a liner consistent with a Class C barrier system. These barrier systems are not necessarily the default barrier systems if Universal Coal can demonstrate that the risks associated with the spoils can be adequately managed without the default barrier systems. While the regulation makes provision for a risk-based approach, there is no guidance by the legislation as to what information the authorities require in a risk-based approach.

10 Conceptual Model

10.1 Aquifers

For the study area, two main aquifers were identified: the weathered and the fractured Karoo aquifers. These are represented by:

- A shallow aquifer formed in the weathered zone;
- A deeper aquifer formed by fracturing of the Karoo sediments, coal measures and dolerite intrusions.

The weathered material in the shallow weathered aquifer consists mostly of decomposed and highly weathered coarse-grained sandstones, with shales and siltstones in some areas. The depth of weathering encountered during drilling was observed to be between 6 and 17 mbgl.

The sustainability in terms of aquifer yields of the shallow weathered aquifer is dependent on the effective recharge, which is the portion of rainfall that infiltrates through the soil and eventually reaches the saturated zone.

Hodgson (2006) reported that the aquifers in the area were not high yielding, with the highest reported yield of 5 l/s associated with a dolerite dyke. The typical yields associated with the sedimentary formations were < 0.5 l/s, and in the order of 1 – 2 l/s where dykes were intersected. The aquifer transmissivity of the weathered material is estimated to be between 0.5 and 1.5 m²/day.

Of all the fractured sedimentary layers the coal seams often show the highest hydraulic conductivity. Historical aquifer tests conducted within this aquifer indicated a low overall hydraulic conductivity.

The estimated hydraulic conductivity from previous aquifer tests correlated well and show aquifer hydraulic conductivity values to be in the expected range of 10^{-1} to 10^{-3}m/d for Karoo aquifers. The values also show the overall low potential of the aquifers, as also stated by Hodgson, 2006.

Based on previous experience, the groundwater recharge in the Karoo fractured aquifer ranges from 1 to 3%. Based on the various studies by GCS for the NCC site their estimated recharge value approaches ~2% of the annual rainfall, and as such a recharge value of 2.25% MAP was used for their latest study in 2014.

10.2 Groundwater Use

Based on the previous hydrocensus data there are no privately owned boreholes or monitoring boreholes within the Study Area. Regionally, groundwater is potentially used for livestock watering, crop irrigation and domestic purposes.

10.3 Groundwater Levels And Flow Directions

On a regional scale, groundwater flow directions follow topography, with exceptions of areas with underground voids (as seen in in the boreholes drill around the proposed Middeldrift open pit which are already impacted by mining) where groundwater levels can be significantly drawn down and these points would divert significantly from this correlation.

Deep, mining impacted groundwater levels (NCCBH2 had a groundwater level of 39.7 mbgl) were found in the proposed Middeldrift open pit area and are likely present for the parts of the Project area in close vicinity to these underground voids. Groundwater levels are shallower towards the Steenkoolspruit, which locally acts as a source.

10.4 Anticipated Impacts – Receptors

10.4.1 Drainage Features

Surrounding river systems can act as potential pathways for contamination, especially when decant or contaminated seepage occur. The closest river system is the Steenkoolspruit system. When decanting occurs from the proposed operations, the contaminated water may enter the streams, where the contaminants are transported to downstream receptors.

Seepage emanating from the open pit and decant areas, may impact on the perched aquifer and migrate towards surface drainage features. Surface water groundwater water interaction is likely to occur, with the streams and river generally acting as gaining streams.

The Steenkoolspruit could potentially be affected by seepage and decant from the proposed Middeldrift open pit.

10.4.2 Pan/Wetland

There is a pan located in the mining area which is proposed to be mined out. However, given the current deep groundwater levels in close proximity to the pan, it is likely that current groundwater contribution to the pan, if any, is already largely reduced due to these adjacent mining activities.

10.4.3 Adjacent Mining Activities

As discussed, barrier pillars are assumed to exist between the NCC and surrounding mining operations. As such, mine interflow is not assumed as part of this study. However, if connections are present or will be created during mining of the Middeldrift resources, this could impact on estimated mine inflows, decant flows and contaminant plume migration as predicted as part of this study.

11 Numerical Model

11.1 Model Planning

11.1.1 Modelling Objectives

The main objective of the model was to develop a steady state and transient flow and contaminant model which would include the following aspects:

- Impacts on groundwater levels and quality due to mining;
- Impact on potential groundwater and surface water receptors due the proposed mining at Middeldrift;
- Potential contaminant plumes that could emanate from the mining area; and
- Assess the potential for mine water decant from the rehabilitated open pit.

11.1.2 Model Confidence Level Classification

An Australian Guideline Class 1 model classification (Barnett, et al., 2012) pursued and was evaluated from a semi-quantitative assessment of the available data on which the model was based, the way the model was calibrated and how the predictions were formulated. The level of confidence depended upon the available data for the conceptualisation, design and construction of the model. The model can thus be used for predicting long-term impacts of sources in low-value aquifers. The model thus serves as a starting point on which to develop higher class models as more data is collected and used.

Consideration was given to the spatial and temporal coverage of the available datasets in order to characterise the aquifer and the historic groundwater behaviour that was useful in model calibration. Factors that may affect the model confidence level during the calibration procedure were considered. These factors included the types and quality of data that was incorporated in the calibration, the degree to which the model was able to reproduce observations, and whether the model was able to represent present-day hydrogeological conditions. The time frame and level of stresses applied in the predictive models were consistent to that of the model calibration process.

11.1.3 Model Setup

During model setup, the conceptual model is translated into a numerical model. This stage entails selecting the model domain, defining the model boundary conditions, discretizing the data spatially and over time, defining the initial conditions, selecting the aquifer type and preparing the model input data. The above conditions together with the input data are used to simulate the groundwater flow in the model domain for pre-mining steady state conditions.

MODFLOW, a modular three-dimensional groundwater flow model developed by the United States Geological Survey (Harbaugh *et al*., 2000) was used for modelling purposes. MODFLOW uses 3D finite difference discretisation and flow codes to solve the governing equations of groundwater flow. MODFLOW NWT (Niswonger *et al*., 2011) was used in the simulation of the groundwater flow model. Both are widely used simulation codes and are well documented. GMS 10.3.8, a pre- and post- processing package for the MODFLOW modelling code was used for the construction of the numerical model.

MT3DMS is a 3D model for the simulation of advection, dispersion, and chemical reactions of dissolved constituents in groundwater systems. MT3DMS uses a modular structure similar to the structure utilized by MODFLOW and is used in conjunction with MODFLOW in a two-step flow and transport simulation. Heads are computed by MODFLOW during the flow simulation and utilised by MT3DMS as the flow field for the transport portion of the simulation.

11.2 Model Domain

The model domain (Figure 11-1) is irregularly shaped with dimensions of 36 km by 25 km. A rectangular mesh was generated for the model domain, consisting of 210 rows and 269 columns. The mesh was refined in the model domain to cell sizes of 75 m by 75 m in the area surrounding the Project site, with cells gradually coarser further away from the mining area (resulting in a total of 202,676 active cells for the four layers modelled). Although a smaller grid size may result in prolonged running time, it was important to refine the model close to the Project site to properly delineate geological units and to calculate the groundwater gradient and pollution plumes more accurately in the direct vicinity of the activities.

The model consists of four layers to allow for discretisation between the weathered and fractured lithologies. The weathered aquifer consisted of one layer of 30 m thickness. While the second layer has a variable thickness ranging from 6 to ~100 m and representing the fractured aquifer. The variable thickness is the result of the coal seam layer, which was simulated separately. The No. 2 seam coal floor contours of the entire project area were collated and used as the bottom elevation of the third layer (6 m thickness). This layer is important in terms of inter-mine flow. The fourth layer represents the lower slightly fractured aquifer but is unlikely to contribute significantly to flow in the model. Topographical contour data used to interpolate the surface topography; the data has a 5 m resolution. All the drain and rivers boundary conditions simulating rivers and stream were constructed in the top layer. Active mining areas were simulated as drain cells in the 3rd layer (No. 2 seam). The open pits were given the same parameters for layer 1 to 3; while the underground areas were only assigned specific parameters to layer 3.

11.3 Boundary Conditions

Boundary conditions express the way in which the considered domain interacts with its environment. In other words, they express the conditions of known water flux, or known variables, such as the hydraulic head. Different boundary conditions result in different solutions, hence the importance of stating the correct boundary conditions.

Boundary condition options in MODFLOW can be specified either as:

a. Specified head or Dirichlet; or

b. Specified flux or Neumann; or

c. Mixed or Cauchy boundary conditions.

Local hydraulic boundaries were identified for model boundaries. They were represented by local perennial and non-perennial water courses and topographical highs and delineated the entire model domain. These hydraulic boundaries were selected far enough from the area of investigation to not influence the numerical model behaviour in an artificial manner. The model boundaries and model grid are shown Figure 11-1. Table 11-1 provides a summary of the boundaries, boundary descriptions and boundary conditions specified in the hydrogeological model.

Table 11-1: Identification Of Real-World Boundaries And Adopted Model Boundary Conditions

Boundary	Boundary Description	Boundary Condition
Internal boundaries	Flux and mixed types.	Mixed type: Drain cells for non-perennial streams. Recharge is constant for the whole model domain. Recharge flux is applied to the highest active cell. A river boundary condition was used for the Olifants River. Evapotranspiration (ET) was included across the model domain.
North	Stream boundary condition – perennial stream. Topographical boundary – no flow boundary type.	Catchment boundary (no flow boundary) and streams (drain boundary condition).
East	Topographical boundary – no flow boundary type.	Catchment boundary (no flow boundary).
South	Stream boundary condition – perennial stream. Topographical boundary – no flow boundary type.	Catchment boundary (no flow boundary) and streams (drain boundary condition).
West	Stream boundary condition – perennial stream. Topographical boundary – no flow boundary type.	Catchment boundary (no flow boundary) and streams (drain boundary condition).

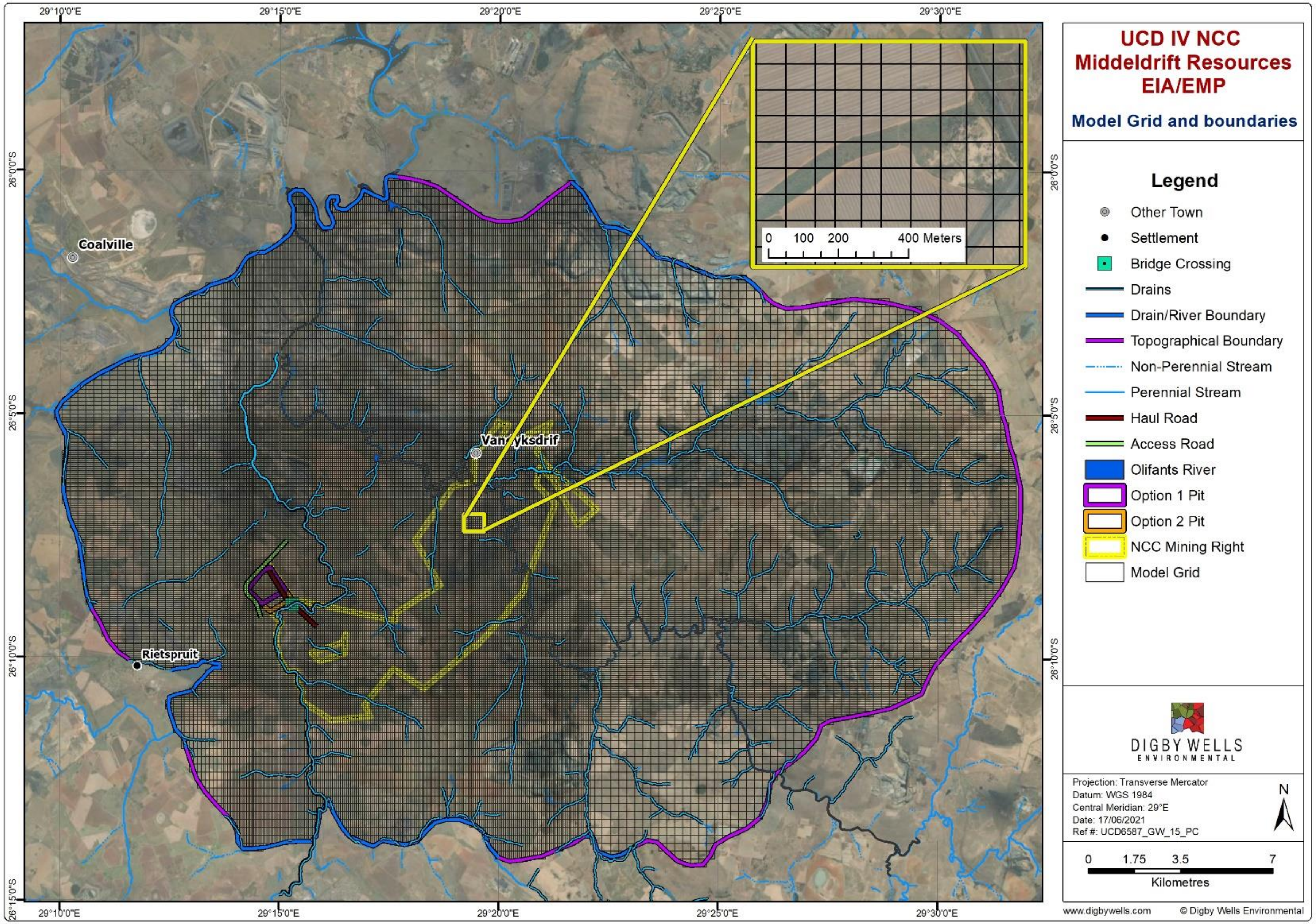


Figure 11-1: Numerical Model Domain, Grid and Boundaries

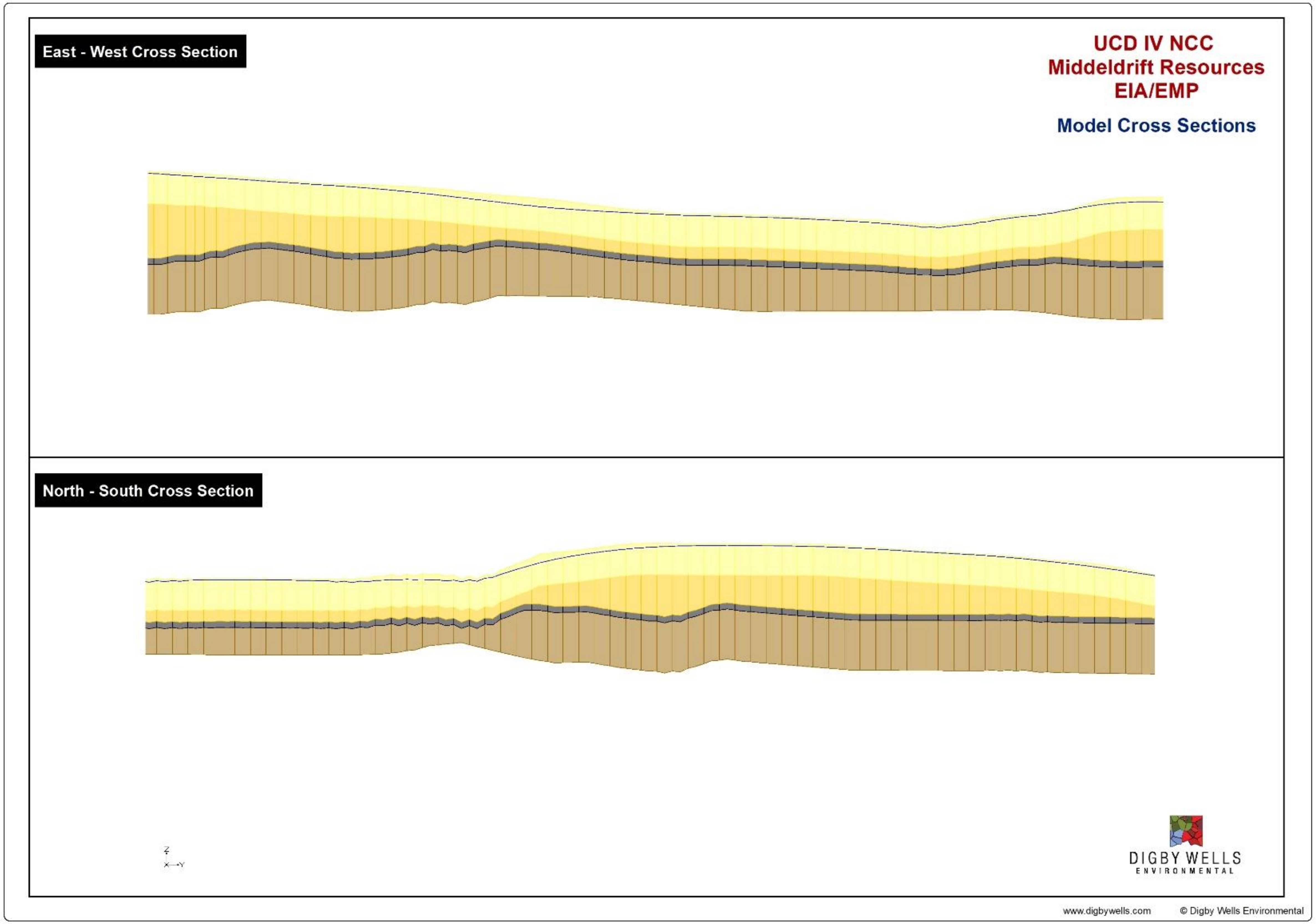


Figure 11-2: Numerical Model Cross Sections

11.4 Model Simulation

Prior to the simulation of the mining and dewatering activities, a baseline (pre-mining) steady state groundwater flow model was set-up and calibrated. The objective of the steady state model was to simulate the groundwater system in the region for the current situation (2021). The impacts of mining activities for the operational and post-closure phases will then be determined by comparing the transient state results with the steady state results.

11.4.1 Calibration

Digby Wells collated the most recent borehole data and hydrocensus information available for the Project site. The steady state model was calibrated with this data to produce a model simulating the pre mining groundwater conditions. A total of 21 observation boreholes were used for the steady state calibration, based on the most recent groundwater level data.

The model was calibrated by varying model input data over realistic ranges of values until a satisfactory match between simulated and observed water level data was achieved.

Since recharge and permeability are dependent on each other via the measured heads, the model was not calibrated by changing the permeability and recharge simultaneously. The permeability was calibrated based on the aquifer test results, while the recharge value was adjusted manually until a best fit was obtained.

Model parameter values and hydrologic stresses determined during the steady-state calibration were used to simulate a transient response. The groundwater level data (NCCBH1 and NCCBH2,; and the dry boreholes drilled into the underground voids, viz. NCCBH3 and NCCBH4) used for calibration around the Middeldrift area indicated that an impact on groundwater levels had already been caused by the adjacent underground workings.

Historically, hydrocensus borehole Gw-MID1 located within the proposed Middeldrift open pit also had a deep water level (~60.95 mbgl in 2012), this borehole could possibly have been drilled into the Phoenix Mine underground (GCS, 2014). It was therefore deemed necessary to include these underground workings as drains during the calibration process.

The Modflow-NWT package was used to solve the partial differential equations. Convergence criteria of a head change of 10^{-3} m were selected. After model calibration a good correlation was obtained between the simulated and observed groundwater elevation (Figure 11-4). The calibration was deemed acceptable with a Mean Residual Head of 0.81, a Mean Residual Absolute Head of 3.6 and a Root Mean Square Error (RMSE) of 4.38.

A water balance error (all flows into the model minus all flows out of the model) of less than 0.5% is regarded as an accurate balance calculation. The mass balance for entire model domain achieved a water balance error of less than 0.2%.

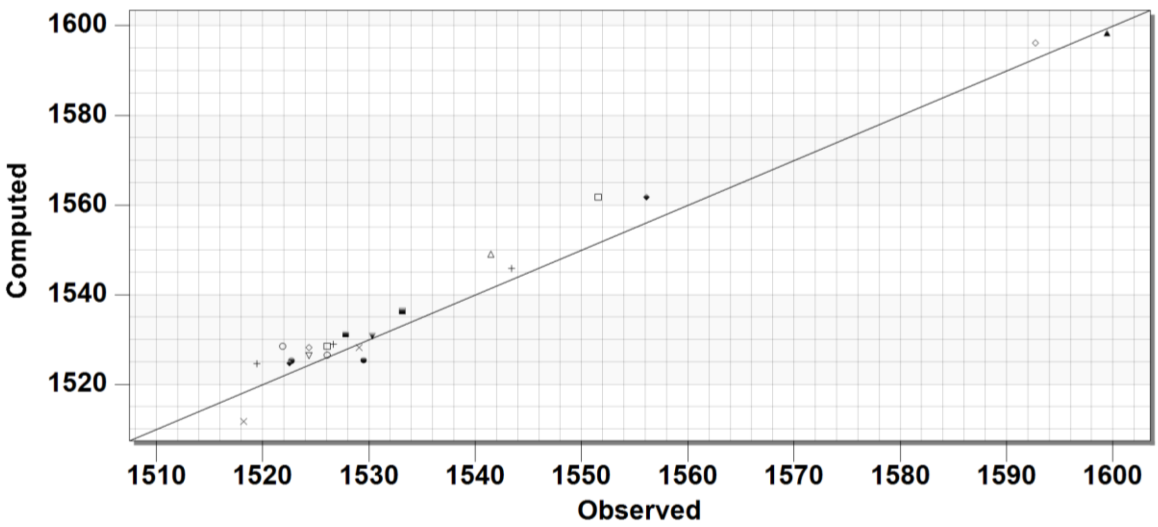


Figure 11-3: Correlation between observed and calculated heads

11.4.2 Aquifer Hydraulic Conductivity

Initial estimates of the hydraulic conductivity for the different geological units were obtained from previous aquifer test data and based on expert knowledge from other nearby model sites. These hydraulic conductivity values were assigned to hydrogeological layers within the model area. The initial estimates were used for a combination of Parameter ESTimation (PEST) and manual calibration. The resulting calibrated hydraulic conductivity values for each layer as summarised in Table 11-2.

Table 11-2: Calibrated values of horizontal and vertical hydraulic conductivities

Lithology	Hydraulic Conductivity		Porosity
	Horizontal	Vertical	
	[m/d]	[m/d]	
Weathered Aquifer	0.02	0.001	0.05
Fractured Aquifer	0.008	0.001	0.05
Slightly Fractured Aquifer	0.0002	0.00002	0.05
Open pit (post closure)	2.5	0.25	0.25
Note/s: m/d - metres per day			

11.4.3 Other Model Parameters

The groundwater recharge in the Karoo fractured aquifer ranges from 1 to 3%. Approximately 15.5 mm/annum, or 2.25% of the average annual precipitation (MAP of 689 mm/annum was applied to the model. The recharge flux applied to the highest active cell. A 20% recharge was used for the Middeldrift backfilled open pit.

Other model parameters used in the calibrated model were as follows:

- Non-perennial streams:
  - Drain level at 5 m below surface level; and
  - Drain conductance of 0.4 $m^2/d/m^2$.
- River (Olifants River) :
  - Head level at surface level;
  - River bottom level at 5 m below surface level; and
  - River conductance of 0.5 $m^2/d/m^2$.
- Mine drains:
  - Drain conductance of 0.2 $m^2/d/m^2$.
- A specific storage (Ss) value of 1 e^{-5} was used for the upper layer and 8 e^{-6} for layer 2 to 4. The specific yield (Sy) for the first layer was assumed as 0.01.
- Evapotranspiration was used, a value of 0.001 m/d was used which is average for grasslands, an extinction of 1m was simulated.

11.4.4 Simulated Water Levels And Flow Direction

The simulated groundwater levels for the current situation are shown in Figure 11-4. The groundwater levels show the general north to northwest flow direction of groundwater across the model domain, with highest groundwater levels along the south-eastern model boundary at the topographical divide and lowest groundwater levels at the northern end of the model, where the hydrological outflow point for the model is situated. Locally in the Middeldrift area, groundwater flows towards the southeast and drains towards the Steenkoolspruit.

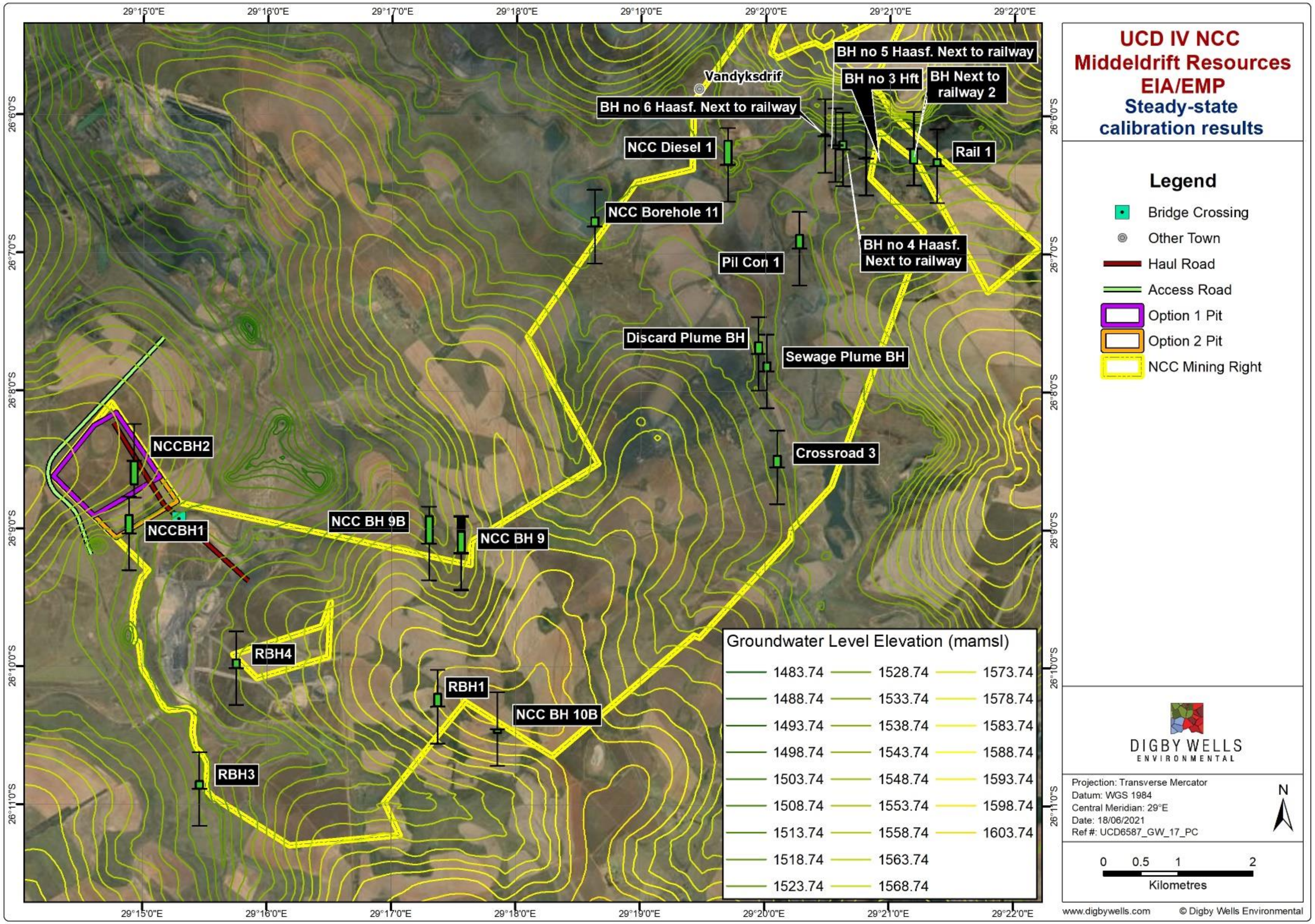


Figure 11-4: Steady-state calibration results

11.5 Transient State Flow Simulation

Transient flow simulation was carried out to estimate groundwater drawdown for the operational phase and groundwater recovery in the post-closure phase. The transient flow model was based on coal seam floor depths and the latest mine schedule as provided by Universal Coal (Figure 7-4 and Figure 7-5). The current LoM is 11 years for Option 1 and 14 years for Option 2 in total.

In addition, increased infiltration was modelled for the backfilled open pit. A seepage rate at ~20% of MAP was assigned for the backfilled, rehabilitated Middeldrift open pit area for the post-closure phase.

11.6 Mass Transport Simulation

Mass transport calculations were carried out for the open pit. Contamination from the open pit can occur when contaminated water from the backfill infiltrates into the surrounding aquifer. This will most likely only occur post-closure when water levels return to approximate pre-mining conditions. A modelling scenario assuming full backfill and rehabilitation of topsoil and vegetation within the open pit areas was carried out to calculate the expected plume extent.

11.6.1 Dispersion And Diffusion

No in-field verification of dispersion was available for this study. However, representative, generic values for dispersion and parameters have been used as input into the numerical model. The longitudinal dispersion was set at 50 m, with the following ratios applied for transverse dispersion:

- Horizontal transverse dispersion/longitudinal dispersion: 0.1; and
- Vertical transverse dispersion/longitudinal dispersion: 0.01.

11.6.2 Effective Porosity

Effective porosity input values for the weathered and fractured aquifers were assumed as 0.05 and 0.25 for the backfilled open pit. These values are based on previous investigations in similar geological settings.

11.6.3 Selection Of The Contamination

As the main source of contamination with coal mining is the weathering of pyrite, the contaminant of choice is sulphate that is released, together with acidity, due to the solution of pyrite. The input concentrations were based on typical input concentrations for coal open pits. Conservatively, a value of 2 000 mg/l was used as input and is assumed a reasonable concentration as based on the geochemical composition of the coal materials (Section 9). This concentration was kept constant over the post-closure period.

11.7 Model Limitations and Exclusions

Groundwater models are inherently simplified mathematical representations of complex aquifer systems and this simplification therefore inevitably limits the accuracy with which groundwater systems can be simulated in general and lead to numerous sources of error and uncertainty. Model error commonly stems from practical limitations of grid spacing, time discretisation, parameter structure, insufficient calibration data, and the effects of processes not simulated by the model. These factors, alongside unintentional errors in field observations and measurements, result in uncertainty in the model predictions. Limitations of models are the result of generalisations, interpretations and assumptions made in attempting to simulate the natural environment.

An Australian Modelling Guideline Class 1 was assigned to the model due to the available data and the calibration which was achieved against heads. No information on fluxes (inflows), as well as an independent measurement of the recharge was available. Class 1 models are often used to provide an initial assessment of the problem and it is subsequently refined and improved to higher classes as additional data is gathered (often from a monitoring campaign that illustrates groundwater response to a development).

Model error and uncertainty are not uniformly distributed. Majority of the data available is located around the mining areas. Because there are only a limited number of boreholes and other hydrogeological data available to characterise the aquifer system, a level of uncertainty exists regarding how representative the measured values are of the average properties in the areas without data.

The heterogeneous subsurface within the relatively large model area, results in hydraulic conductivity being simulated as uniform broad areas and may not reflect the true complexity of the geology.

Nevertheless, models are a simplified approximation of reality. All efforts have been made to base the model on sound assumptions and was calibrated to observed data, however the results obtained from this exercise should be considered in accordance with the assumptions made. Limitations of models are the result of generalisations, interpretations and assumptions made in attempting to simulate the natural environment. The following limitations is true for the numerical groundwater model:

- The top of the aquifer is represented by the surface topography and used to construct a representative spatial extent;
- The model simulates the fractured rock environment as an equivalent porous medium, which is an overall simplification of the flow process;
- No inter-mine flow or impacts of other adjacent mining related activities were included;
- It is assumed that the adjacent underground workings were unflooded during the mining of the proposed pit;
- The flooding status and coal floor elevations of the adjacent underground workings will have a large effect on the final impact of the open pit and should be further investigated;

- No groundwater abstraction of external users was simulated;
- Recharge rates were assumed as constant throughout the simulated period; therefore, no wet-dry cycles are simulated; and
- Detailed geology as well as faults and dykes were not included;

12 Groundwater Impact Assessment

The aim of an impact assessment is to strive to avoid damage or loss of ecosystems and services that they provide and where they cannot be avoided, to reduce and mitigate these impacts (DEA, 2014). Offsets to compensate for the loss of habitat are regarded as a last resort, after all efforts have been made to avoid, reduce and mitigate.

The potential impacts of the proposed activities on groundwater resources are shown below per phase of the mine. The impacts were derived based on previous experience and literature review. The impacts shown below take into account the worst-case scenario; however, these impacts need to be considered during the planning phase.

12.1 Construction Phase

The construction phase will consist of building of the surface infrastructure of the mine, the construction of box cuts for the open pit (option 1 and option 2). The following potential impacts could result from these on-site activities (Table 12-1 and Table 12-2).

Table 12-1. Impacts during the Construction Phase – Spillages

Dimension	Rating	Motivation	Significance
Activity and Interaction: Fuel storage, construction vehicles causing potential groundwater contamination			
Impact Description: site contamination of groundwater due to hydrocarbon spillages and leaks from construction vehicles.			
Prior to Mitigation/Management			
Duration	1	Any occurrence could be reversed within a months' time.	Negligible (negative) - 10
Extent	1	Impacts will be limited to specific isolated parts of the site.	
Intensity	2	Expected minor impacts on the biological or physical environment; damage can be rehabilitated internally.	
Probability	3	There is a possibility of this impact to occur.	
Nature	Negative		
Mitigation/Management Actions			
• Regular service of vehicles in designated repair bays. • Refuelling of vehicles only in designated areas.			
Post-Mitigation			
Duration	1	Any occurrence could be reversed within a months' time.	Negligible (negative) - 6
Extent	1	Impacts will be limited to specific isolated parts of the site.	
Intensity	2	Expected minor impacts on the biological or physical environment; damage can be rehabilitated internally.	
Probability	1	With mitigation measures in place it is not expected to happen.	
Nature	Negative		

Table 12-2. Impacts During The Construction Phase - Stripping.

Dimension	Rating	Motivation	Significance
Mine dewatering causing groundwater level drawdown			
Impact Description: Small scale dewatering during stripping of topsoil and softs.			
Prior to Mitigation/Management			
Duration	1	Any occurrence could be reversed within a months' time.	Negligible (negative) - 8
Extent	1	Impacts will be limited to specific isolated parts of the site.	
Intensity	2	Expected minor impacts on the biological or physical environment; damage can be rehabilitated internally.	
Probability	2	There is a possibility of this impact to occur if the box cuts or the stripping goes to below the groundwater table.	
Nature	Negative		
Mitigation/Management Actions			
• Keep the stripping time as short as possible. • If the groundwater level is intercepted, the extent and depth of the stripping areas should be as minimal as possible.			
Post-Mitigation			
Duration	1	Any occurrence could be reversed within a months' time.	Negligible (negative) - 6
Extent	1	Impacts will be limited to specific isolated parts of the site.	
Intensity	2	Expected minor impacts on the biological or physical environment; damage can be rehabilitated internally.	
Probability	1	Expected not to happen if box cut and stripping depth can be limited.	
Nature	Negative		

12.2 Operational Phase

12.2.1 Groundwater Level Drawdown

The mine floor elevation is below the general groundwater level thus causing groundwater inflows into the open pit mining areas from the surrounding aquifers during operations. The mining areas require active dewatering to ensure a safe working environment. Pumping water that seeps into the mining areas to the surface will cause dewatering of the surrounding aquifers and an associated decrease in the groundwater level within the zone of influence of the dewatering cone.

The zone of influence of the dewatering cone depends on several factors including the depth of mining below the regional groundwater level, recharge from rainfall to the aquifers, the size of the mining area and the aquifer transmissivity and other mining activities, amongst others. The 3D numerical groundwater flow model was used to simulate the development of the drawdown cone over time in the study area.

The latest mine schedule for the proposed Middeldrift option 1 and option 2 were incorporated into the predictive model scenarios. It must be noted that there is an existing impact on the groundwater levels in the proposed open pit area due to the adjacent underground workings. These underground workings which were dry in the investigated area has resulted in lowering of the groundwater level in the area.

Historically, borehole Gw-MID1 had also been impacted by these workings (GCS, 2014), this borehole was however reported to be dry during the 2020 monitoring period. This borehole had a deep water level (~60.95 mbgl in 2012). Borehole NCCBH2 drilled on the eastern part of the proposed Middeldrift also has a deeper mining impacted water level of ~39m mbgl due to the dewatering caused by the adjacent underground workings. Borehole NCCBH3 and NCCBH4 both encountered mine voids at 46 mbgl and 50 mbgl respectively and were dry at the time of the investigation. This indicates the underground workings are not flooded and probably drain into the adjacent open pit spoils to the far west and northeast.

Nevertheless, it is expected that the main impact on the groundwater environment will be dewatering of the surrounding aquifer. Based on the model simulation, it is expected that no external user boreholes or springs will be impacted by the mining.

The simulated extent of drawdown extends 300 m to 600 m from the active mining area in 2028 and 2032 (end of LoM for option 1) seen in Figure 12-3. The extent of drawdown for option 2 is slightly larger than for option 1 due to the larger mining area (Figure 12-3). The extent of mining in 2038 (end of LoM for option 2) could also extend ~600-1000 m from the mine workings.

The proposed mining is also likely to impact on the baseflow contribution to the Steenkoolspruit in the area of mining, due to the extent of drawdown. For option 1 a 34% reduction in baseflow over a ~1 km river segment of the Steenkoolspruit was observed. For option 2, the reduction was 41% while the open pit was operational. The baseflow increases again post-closure to near pre mining volumes.

It is important that the boreholes that are to be mined out are comprehensively sealed and grouted before mining commences to prevent potential contamination to the underlying aquifer. The impact significance is calculated as minor (Table 12-3).

12.2.2 Impact On Aquifer Yield (Groundwater Abstraction Volumes)

It was possible to calculate the groundwater inflow into the proposed Middeldrift options 1 and 2 from the numerical model. The computed inflow is calculated as shown in Figure 12-1 and Figure 12-2 based on the provided mine schedules and coal floor levels. The impact significance is minor (Table 12-4).

It must be cautioned that these calculations have been done using simplified assumptions for a homogeneous aquifer. Calculated inflow volumes must be considered as an order of magnitude only, with inflows that could deviate in reality from this. Model results should thus be updated as more detailed information for Middeldrift area becomes available.

It is important to note that the not flooded, adjacent underground workings were included in the model for the inflow estimates. Therefore, the simulated groundwater inflows are lower than expected due to the existing partially dewatered aquifer. The groundwater inflows would likely be higher should adjacent workings be flooded during the operational phase of the Middeldrift open pit.

The inflow into the option 1 mine schedule was simulated between 200 m^3/day initially and reach ~140 m^3/day at the end of LoM in 2032 (Figure 12-1). For the option 2 schedule, the inflows increased from ~80m^3/day to ~200 m^3/day in 2038 (end of LoM) as seen in Figure 12-2. No inter-mine flow was simulated, the interaction of the proposed open pit and the underground workings should be further assessed.

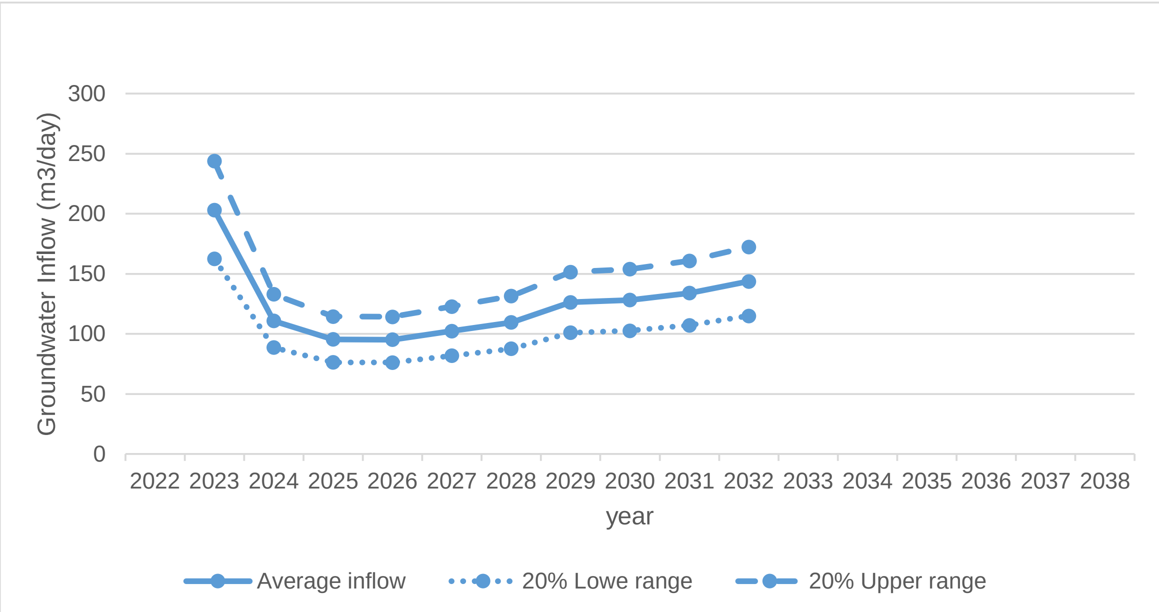


Figure 12-1. Simulated Groundwater Inflows Into The Open Pit– Option 1

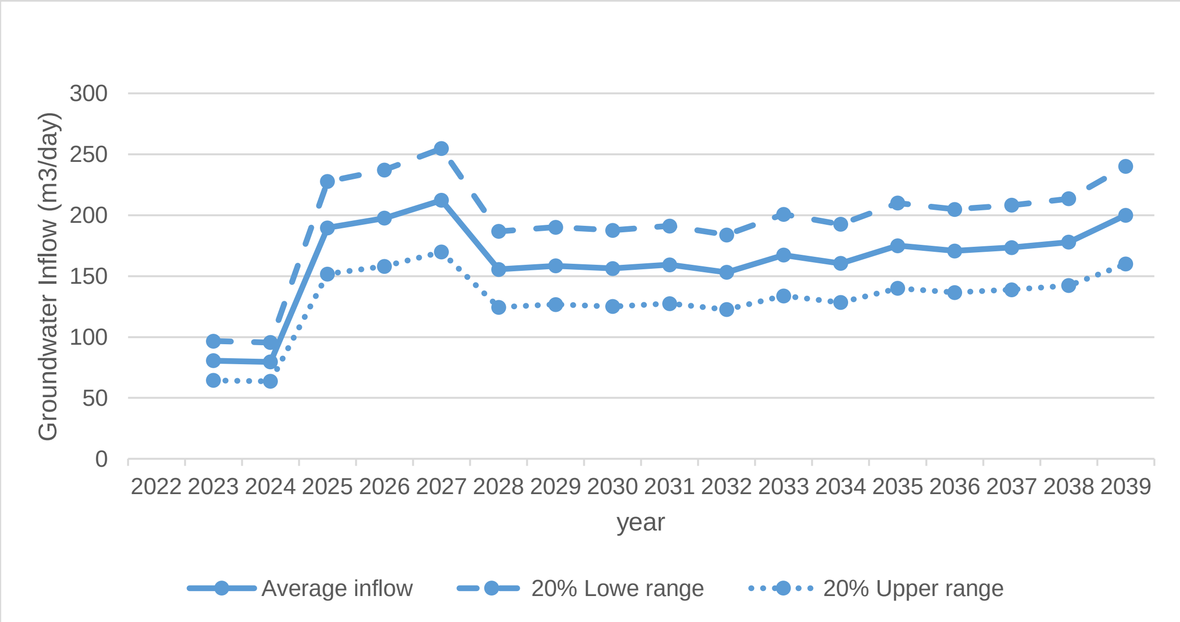


Figure 12-2. Simulated Groundwater Inflows Into The Open Pit – Option 2

12.2.3 Groundwater Quality (Contamination Of The Surrounding Aquifers)

The life of mine for the Middeldrift is planned until 2032 for option1 and 2038 for option 2. This allows time for chemical reactions to take place in the mined-out areas to produce Acid Mine Drainage (AMD) conditions. Groundwater flow directions will be directed towards the mining areas due to the mine dewatering. Therefore, contamination will be contained within the mining areas and little contamination will be able to migrate away from the mining area, as rated in Table 12-5.

Table 12-3: Impacts During The Operational Phase – Groundwater Drawdown

Dimension	Rating	Motivation	Significance
Activity and Interaction: Mine dewatering causing lowering of groundwater levels			
Impact Description: Active mine dewatering will be required to ensure dry working conditions in the open pit. The dewatering will cause ground levels to be drawn down in the vicinity of the mining area.			
Prior to Mitigation/Management			
Duration	6	Expected for LoM.	Minor (negative) -42
Extent	2	Limited to Middeldrift open pit and surroundings.	
Intensity	3	Moderate, operational effects.	
Probability	6	It is likely that this impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
• Mining should progress as swiftly as possible to reduce the period of active dewatering. • The mining area extent should be kept to a minimum. • Dewatering of the open pit should stop should as soon as the mining activities cease. • Groundwater levels surrounding the open pit should be monitored on a regular basis throughout the LoM to verify the extent of the cone of drawdown.			
Post-Mitigation			
Duration	5	Expected for LoM .	Minor (negative) -39
Extent	2	Limited to Middeldrift pit and surroundings.	
Intensity	3	Moderate, operational effects .	
Probability	6	It is likely that this impact will occur.	
Nature	Negative		

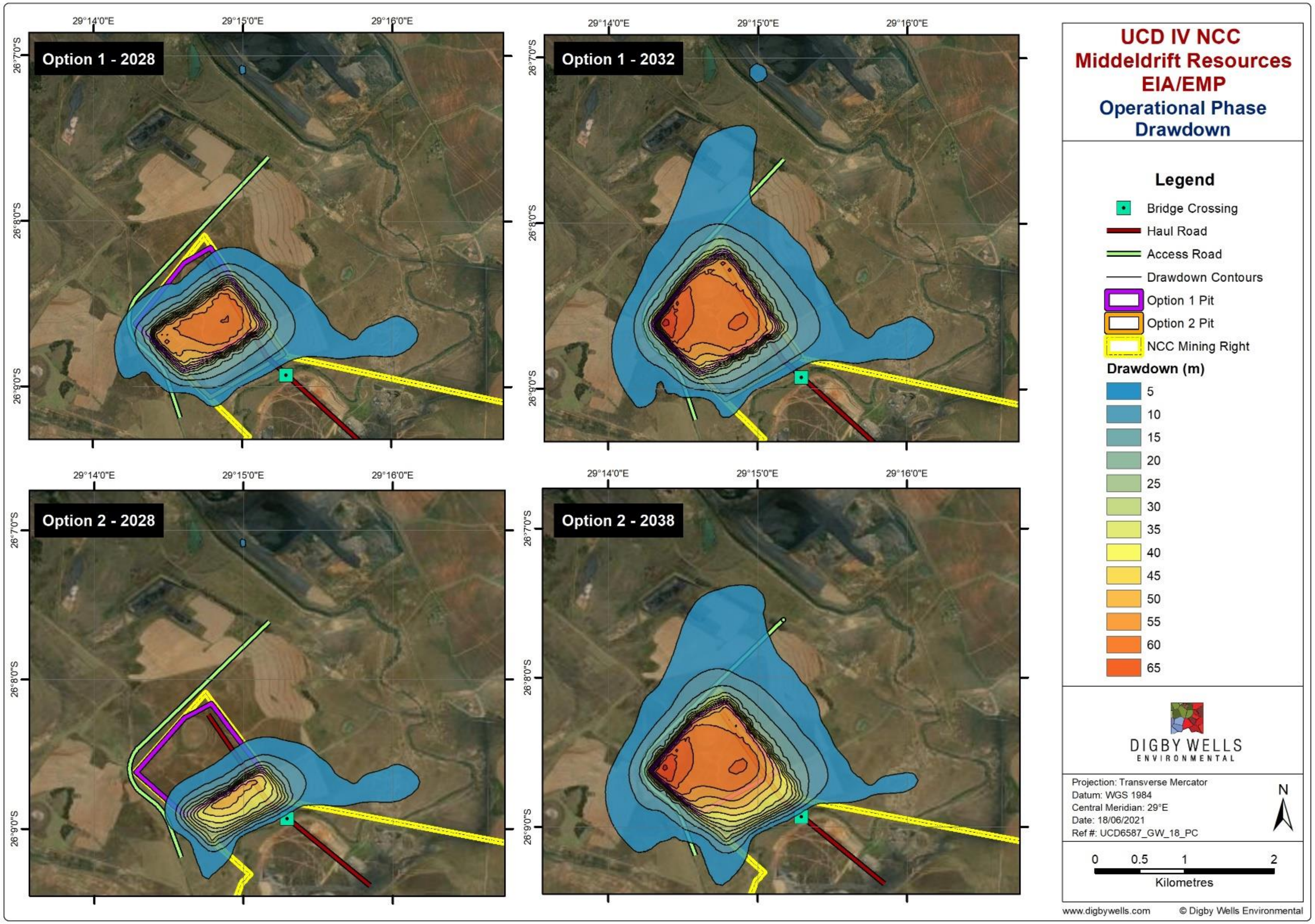


Figure 12-3: Groundwater Cone Of Drawdown During The Operational Phase – Option 1 and 2

Table 12-4: Impacts During The Operational Phase – Groundwater Abstraction

Dimension	Rating	Motivation	Significance
Activity and Interaction: Mine dewatering causing a decrease in groundwater reserves			
Impact Description: Due to active mine dewatering required to ensure dry working conditions in the open pit, certain groundwater volumes will be extracted from the open pit, limiting the groundwater resource.			
Prior to Mitigation/Management			
Duration	6	Expected for LoM and a short period post-closure.	Minor (negative) - 36
Extent	2	Limited to Middeldrift open pit and surroundings.	
Intensity	3	Moderate, operational effects.	
Probability	4	It is probable that this impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
• Mining should progress as swiftly as possible to reduce the period of active dewatering. • The mining area extent should be kept to a minimum. • Dewatering of the open pit should stop should as soon as the mining activities cease. • Dewatering volumes should be monitored frequently throughout the LoM to note deviations from the predicted inflows as soon as possible.			
Post-Mitigation			
Duration	5	Expected for LoM .	Negligible (negative) -33
Extent	2	Limited to Middeldrift pit and surroundings.	
Intensity	3	Moderate, operational effects .	
Probability	4	It is probable that this impact will occur.	
Nature	Negative		

Table 12-5: Impacts During The Operational Phase – Groundwater Quality

<table>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Activity and Interaction: AMD formation in the open pit causing groundwater contamination</td></tr>
<tr><td colspan="4">Impact Description: Due to AMD taking place within the open pit, potential groundwater contamination with sulphate and a lower pH could occur, which would have an impact on the groundwater quality.</td></tr>
<tr><td colspan="4">Prior to Mitigation/Management</td></tr>
<tr><td>Duration</td><td>6</td><td>Expected for LoM and post-closure.</td><td rowspan="5">Negligible (negative) -22</td></tr>
<tr><td>Extent</td><td>2</td><td>Limited to Middeldrift open pit and surroundings.</td></tr>
<tr><td>Intensity</td><td>2</td><td>Negligible effects due to drawdown cone preventing contaminants from spreading.</td></tr>
<tr><td>Probability</td><td>3</td><td>With current limited data available and based on previous experience this impact is probable.</td></tr>
<tr><td>Nature</td><td>Negative</td><td></td></tr>
<tr><td colspan="4">Mitigation/Management Actions</td></tr>
<tr><td colspan="4">• Groundwater abstraction should continue for the LoM to maintain a cone of drawdown.
• Monitoring of groundwater quality in the area surrounding the open pit should continue during LoM.
• Groundwater levels surrounding the mine void should be monitored on a regular basis during LoM to verify the extent of the cone of drawdown.</td></tr>
<tr><td colspan="4">Post-Mitigation</td></tr>
<tr><td>Duration</td><td>5</td><td>Expected for LoM.</td><td rowspan="5">Negligible (negative) -18</td></tr>
<tr><td>Extent</td><td>2</td><td>Limited to Middeldrift open pit and surroundings.</td></tr>
<tr><td>Intensity</td><td>2</td><td>Negligible effects due to drawdown cone preventing contaminants from spreading.</td></tr>
<tr><td>Probability</td><td>2</td><td>With current limited data available and based on previous experience this impact is likely to occur but reduced with mitigations in place.</td></tr>
<tr><td>Nature</td><td>Negative</td><td></td></tr>
</table>

12.3 Post-Closure Phase

In the post-closure phase, the open pit is deemed to be fully backfilled, vegetated and allowed to flood. Water and oxygen will likely react with the backfilled material and as a result Acid Mine Drainage (AMD) / Neutral Mine Drainage (NMD) could peak during this phase. The environmental impact significance is expected to be moderate to high if not mitigated.

12.3.1 Groundwater Quality

Once the mining has ceased, ARD/NMD/SD [2] is still likely to form given the unsaturated conditions in the mining areas and contact of water and oxygen through natural process including rainfall. Therefore, groundwater contaminant plumes are likely to migrate from the mining areas once the water level in the rehabilitated open pit has reached long term steady-state conditions (i.e. each pit water level has reached the decant level). The migration of contaminated water from the rehabilitated open pits has been simulated for 50 and 100 years after closure (i.e., it is assumed that all open pits have been rehabilitated and backfilled) as seen in Figure 12-4.

The contaminant plume emanating from the proposed open pit migrates in a south easterly direction toward the Steenkoolspruit. No impact on third-party boreholes is expected. However, the rehabilitated pit is likely to contribute to the salt load to the Steenkoolspruit. In the form of contaminated seepage towards the stream.

For option 1 a sulphate load of ~200 kg/day could reach the Steenkoolspruit. For option 2 however the simulated sulphate load is estimated to be higher at ~470 kg/day due to the closer proximity of the pit to the Steenkoolspruit.

The interaction between the Middeldrift open pit and the adjacent underground workings were not considered. The interaction should however be assessed as the post closure impacts could differ when the adjacent workings are flooded or remain unflooded (for the purposes of this report they were assumed to be flooded but with negligible flow contribution into the proposed backfilled pit).

It is recommended to conduct surface water blending model to assess the risk associated with the salt load contribution of the base flow.

The results must be viewed with caution as a layered homogeneous aquifer has been assumed. Heterogeneities in the aquifer are unknown and the effect of this cannot be predicted. Furthermore, no chemical interaction of the sulphate with the minerals in the surrounding bedrock has been assumed. As there may be some interaction and retardation of the plume, it is likely that this prediction will represent a worst-case scenario.

[2] [2] ARD-Acid rock drainage; NMD – Neutral mine drainage; SD - saline drainage

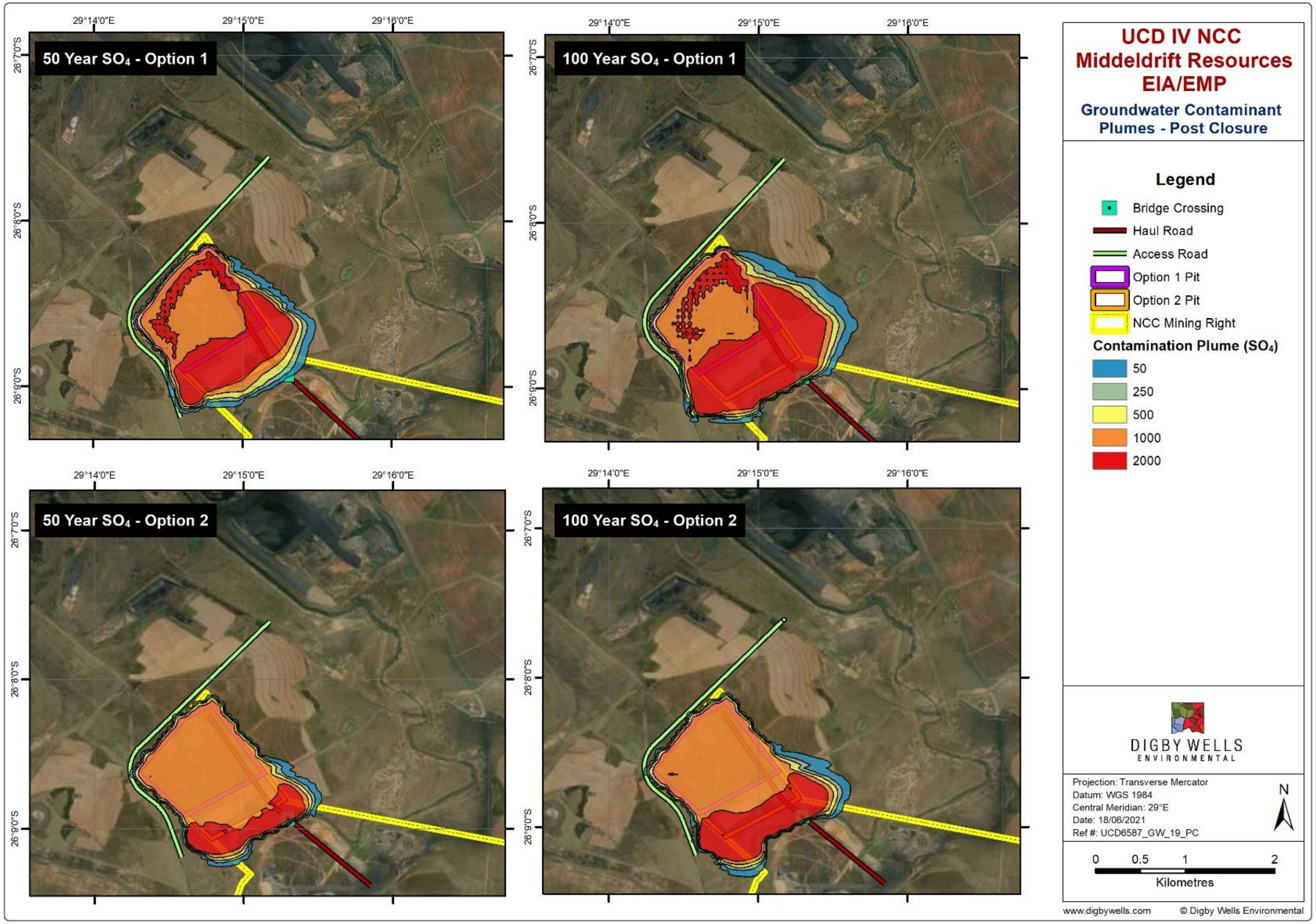


Figure 12-4: Groundwater Contaminant Plumes Post-Closure 50 Years And 100 Years

Table 12-6: Impacts During The Post Closure Phase – Groundwater Quality

Dimension	Rating	Motivation	Significance
Activity and Interaction: AMD in open pit causing groundwater contamination			
Impact Description: Due to AMD taking place within the backfilled open pit, potential groundwater contamination with sulphate and a lower pH could occur, which would have an impact on the groundwater quality.			
Prior to Mitigation/Management			
Duration	7	The impact will remain long after the life of the Project. The impacts are irreversible.	Moderate (negative) -90
Extent	2	Limited to Middeldrift open pit and surroundings.	
Intensity	6	Serious impact on expected on ecosystems and drainage lines within the contaminant plume.	
Probability	6	This impact will likely occur.	
Nature	Negative		
Mitigation/Management Actions			
• Dewatering of the pit should cease as soon as possible after mining activities are completed to allow for groundwater level recovery. • Rehabilitation of the pit to reduce infiltration of rainwater. • Clean water and runoff should be diverted where possible towards the rehabilitated pit as fast as possible after mining has stopped. • Groundwater quality should be frequently sampled to establish if a contaminant plume will migrate.			
Post-Mitigation			
Duration	7	The impact will remain long after the life of the Project. The impacts are however mitigated in duration if proposed mitigation of faster flooding is implemented.	Moderate (negative) -75
Extent	2	Limited to Middeldrift open pit and surroundings.	
Intensity	5	Serious impact on expected on ecosystems and drainage lines within the contaminant plume.	
Probability	6	This impact will likely occur.	
Nature	Negative		

12.3.2 Mine Decant And Groundwater Level Recovery

Decant occurs when the mine water level in the rehabilitated and backfilled workings rebounds to a level above the topographic elevation, resulting in mine water discharging onto surface. Surface decanting refers to direct discharge of mine water to surface through backfilled material, voids, shafts, adits, boreholes and other direct paths.

For open pits, decant takes place at the lowest topographic level that intersects the flow path and/or open pit. The location of the decant positions can be seen in Figure 12-5 for both option 1 and 2. A summary of the decant levels and volume for the open pits can be seen in Table 12-7. The expected significance of the impact is high as seen in Table 12-8.

The decant volume and period to decant is based on a backfilled open pit with no final void and does not take evapotranspiration into account. Based on the available open pit floor elevations all the open pit floors will be partially flooded.

In general, it is expected that the rehabilitated and backfilled areas will only be partially flooded, due to the nature of the mine/coal floor elevation and topography. The flooding/ pit water level recovery is relatively long due to a relative deep open pit and therefore large probably saturated void space. The decant rate for option 2 is likely to be higher than for option 1.

The interaction between the Middeldrift open pit and the adjacent underground workings were not considered. The interaction should however be assessed as the decant status could differ significantly when the adjacent workings are flooded or remain unflooded (for the purposes of this report they were assumed to be flooded but with negligible flow contribution into the proposed backfilled pit.

It is recommended that are drilled into the backfilled open pit to determine the inflow rates as the open pits flood. Therefore, the active monitoring of the water levels in the mining areas should take place so that more precise decant predictions can be made. The lowest positions at each open pit should be surveyed and decant monitored once flow is noted. The decant can be managed by monitoring the mine water level. These positions only need to be monitored once mining and or backfilling has been completed. A decant management plan should be developed for the mine.

Table 12-7 Open pit Mine Volume And Decant Calculations

General information			
	Units	**Option 1**	**Option 2**
Surface area	m^2	971 350	1 442 667
Decant elevation	mamsl	1 555	1 540
Total saturated backfill volume	m^3	64 612 397	71 916 643
Mean annual rainfall	m/a	0.689	0.689
Saturated Backfilled void volume			
25% Porosity	m^3	16 153 099	17 979 161
30% Porosity	m^3	19 383 719	21 574 993
50% Porosity	m^3	32 306 199	35 958 322
Flooding/decant rate			
10% Recharge (incl. GW inflow)	m^3/d	183	272
15% Recharge (incl. GW inflow)	m^3/d	275	408
20% Recharge (incl. GW inflow)	m^3/d	367	545
Time to reach decant elevation			
Most probable scenario (25% Ø and 20% RCH)	**Years**	**121**	**90**

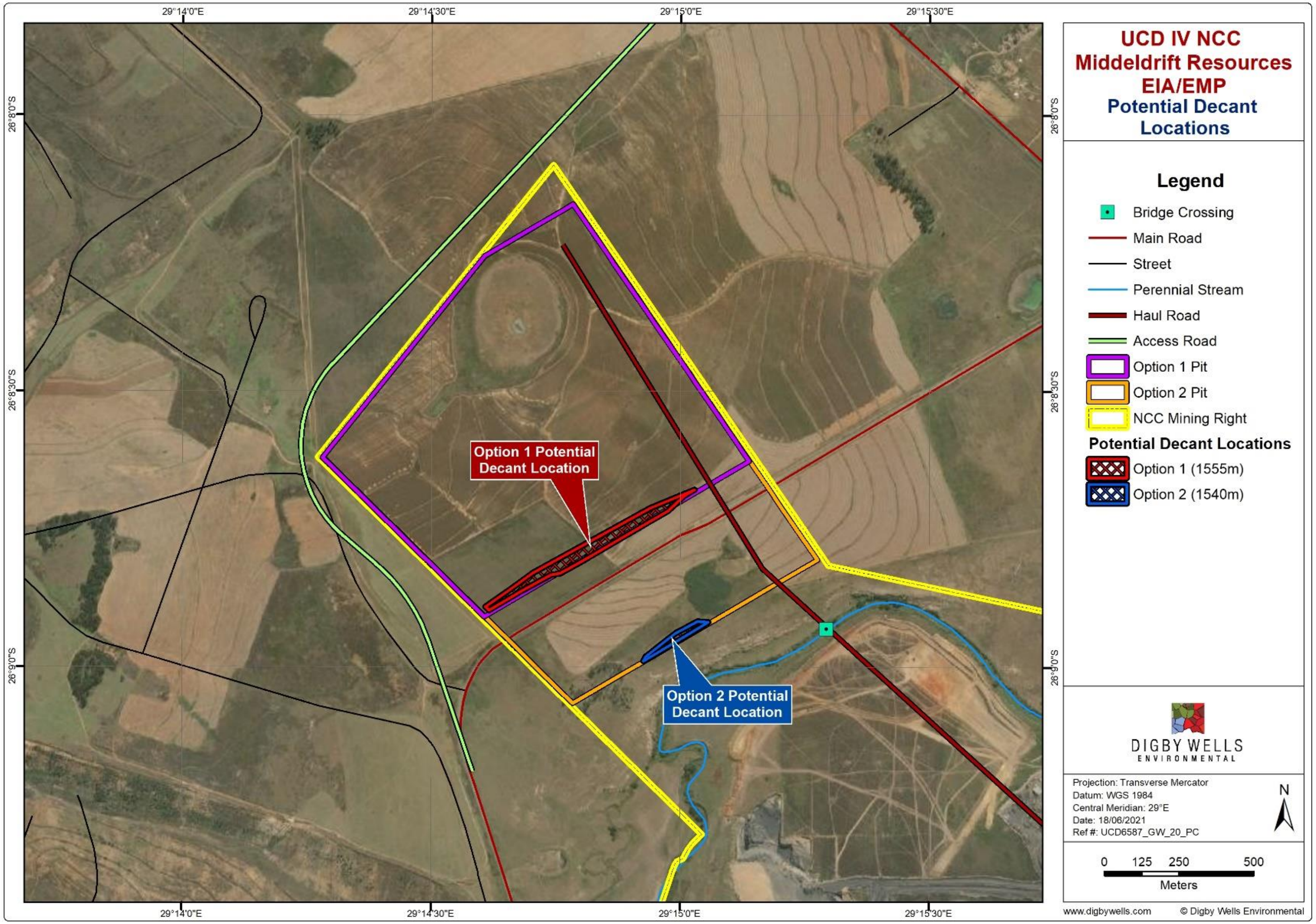


Figure 12-5: Potential Decant Points

Table 12-8: Impacts During The Operational Phase – Decant

Dimension	Rating	Motivation	Significance
Activity and Interaction: Mine decant causing contamination of groundwater			
Impact Description: If groundwater levels within the pit recover to elevations higher than surface elevations, this water may then flow from the backfilled open pit areas and cause groundwater contamination down gradient of the mine.			
Prior to Mitigation/Management			
Duration	7	The impact will remain long after the life of the Project. The impacts are irreversible.	Moderate (negative) -84
Extent	2	Decant points and downgradient.	
Intensity	6	Serious impact on ecosystems within the contaminant plume.	
Probability	5	This impact may occur.	
Nature	Negative		
Mitigation/Management Actions			
• Groundwater level recovery in the rehabilitated open pit should be frequently monitored to create stage curves and predict the final water recovery level. • Rehabilitation of the pit to reduce infiltration of rainwater into the dump to reduce seepage generation. • Installation of groundwater abstraction boreholes at decant points to reduce water level and prevent decant flow and treatment of the abstracted water.			
Post-Mitigation			
Duration	6	The impact will remain long after the life of the Project. The impacts are irreversible.	Minor (negative) -60
Extent	2	Limited to the site only.	
Intensity	6	Serious impact on ecosystems within the contaminant plume.	
Probability	2	This impact is unlikely to happen.	
Nature	Negative		

Table 12-9: Impacts During The Post-Closure Phase – Groundwater Recovery

Dimension	Rating	Motivation	Significance
Activity and Interaction: Mine Dewatering and residual effect on rebounding groundwater levels			
Impact Description: Due to the dewatering activities during the operational phase, groundwater levels surrounding Middeldrift pit will be subdued at the start of the post-closure phase, after it will gradually recover towards pre-mining levels.			
Prior to Mitigation/Management			
Duration	6	Reduced groundwater levels will be fully recovered within 90-120 years, no groundwater users to be impacted. Baseflow volume is minor.	Minor (negative) - 42
Extent	2	Limited to Middeldrift open pit and surroundings.	
Intensity	3	Moderate, short-term effects are expected.	
Probability	6	This impact is likely to occur.	
Nature	Negative		
Mitigation/Management Actions			
• Dewatering of the open pit should cease as soon as possible after mining activities are completed to allow for groundwater level recovery. • Groundwater level recovery should be frequently monitored to identify deviations from the predicted recovery rate. • Groundwater quality should be frequently sampled to establish if a contaminant plume will migrate. • Clean water and runoff should be diverted where possible towards the open pit to flood areas as fast as possible after mining has stopped.			
Post-Mitigation			
Duration	5	Reduced groundwater levels will be fully recovered within 90-120 years, no groundwater users to be impacted. Baseflow volume is minor.	Minor (negative) - 39
Extent	2	Limited to Middeldrift open pit and surroundings.	
Intensity	3	Moderate, short-term effects are expected.	
Probability	6	This impact is likely to occur.	
Nature	Negative		

12.4 Cumulative Impacts

The main impacts of open pit mining of coal are groundwater resource reduction, drawdown and contamination. In addition, a risk of decant exists when water levels in the open pit recover to above the lowest topographical elevation. Other open pit coal mining operations are present within the wider area surrounding the proposed Project area, including the NCC Roodekop mining operation southeast of the Project area across the Steenkoolspruit. Furthermore, other open pit mines are found southwest of the proposed Middeldrift open pit opposite the NCC Roodekop workings.

However, as mentioned previously a section of the Phoenix/Rietspruit Mine underground workings surrounds the proposed Middeldrift open pit. A 30 to 200 m barrier pillar between the proposed project and the underground workings is found to the southwest. Along the northwest and northern boundary of the proposed open pit the boundary pillar is likely to be ~50 m wide. On the eastern side there are section where the barrier pillar is 30 m wide, while certain areas the pillar is 300 m wide (assuming the available mining extents of the Phoenix/Rietspruit Mine underground workings are correct). Given the narrow boundary pillar, inter-mine flow is likely to be a risk to the proposed Middeldrift open pit, and the potential interaction between the mining areas should thus be further investigated as the significance and timing of the envisaged impacts may change through the LoM. This investigation will also become necessary to apportion any closure liabilities. It is expected that groundwater resources, drawdown and baseflow to the Steenkoolspruit may be impacted upon by numerous mines including the proposed Middeldrift open pit.

Contamination from open pit areas, waste rock dumps and other unlined facilities may also cause a cumulative effect on groundwater quality in areas in between the mining operations. In the post-closure phase there is a possibility of these contaminant plumes to join and thus impact upon a larger area in between mining operations. This could impact on other groundwater users, groundwater dependant ecosystems and surface waters within these areas. If decant flows towards downgradient streams it can impact on surface water quality, and if multiple decants would occur into the same stream, there would be a cumulative impact on the water quality due to increased salt load. This could be a cumulative impact of high significance, and the possibility of decant for each proposed mining activity should be properly mitigated.

12.5 Unplanned And Low Risk Events

It is perceived that the Phoenix/Rietspruit Mine underground section surrounding the proposed Middeldrift open pit is dry or unflooded (based on the results of borehole drilling). It is unknown if these areas are likely to remain in the current state on the long term. It may be possible that as the proposed Middeldrift open pit is rehabilitated and allowed to flood, seepage along the coal seam can occur towards these dry workings. This could alter the manner (timing and volume) in which the proposed Middeldrift open pit floods. In the same way if these Phoenix/Rietspruit Mine underground workings fill up with water then seepage could occur towards the proposed Middeldrift open pit and result in an increased flooding rate and decant volume. These interactions need to be further investigated.

13 Groundwater Management Plan

In the sections below all actions and mitigations that should be implemented as part of the groundwater management plan are detailed per relevant mining phase.

13.1 Construction Phase

- Separate clean and dirty runoff and divert dirty water to adequately sized pollution control dams;
- Prevent dirty water runoff from leaving the general mining area (stormwater management);
- Minimise dirty footprints;
- A sufficient supply of absorbent fibre should be kept at the site to contain accidental spills;
- Monitoring boreholes should be monitored based on the WUL conditions; and
- Contain dirty water in lined dams and re-use dirty water for dust suppression.

13.2 Operational Phase

- Restrict the impact of contaminated groundwater to the mining area and mitigate the impact on groundwater levels and stream flow reduction in the catchment.
- Minimise the extent of groundwater contaminant plume migration and decant volumes, all mining areas should be free draining to reduce the pit recharge rate post closure;
- A site assessment re-calculating the decant volumes using numerical model results and spreadsheet calculations should be carried out every two years based on the rehabilitation design of open pit;
- Re-estimations of the recharge based on the used capping and determination of the backfill porosity into each pit should be assessed when backfilling is complete. This will improve the accuracy of the decant volumes and time-to-decant to be expected;
- Delineations of mining areas, contribution of each of those mining areas to the constructed decant points and anticipated decant volumes (average and seasonal variations) should be assessed and/or confirmed and these volumes should correspond to values in the site water balance;
- All boreholes to be mined out should be grouted and sealed to prevent cross contamination of aquifers;
- Mine water must be used or pumped to dirty water dams or pollution control facilities in order to avoid deterioration of the mine water. The longer the mine water resides in the pit the higher the TDS will be;
- As much as possible coal must be removed from the open pit mine during the operational phase;

- Carbonaceous rocks (especially shale) and discard should be placed in the deepest part of the pit (as far as practical possible) and below the long-term pit water level in order to ensure that it is flooded, and that pyrite oxidation is minimised;
- Soft overburden and weathered rock should be placed at the top of the backfill in order to minimise oxygen diffusion into the pit;
- The mined-out sections of the pit should be backfilled, compacted and rehabilitated where practically possible. Concurrent rehabilitation is practiced at the mine. Rehabilitation can include covering the backfill with a topsoil layer as well as vegetation thereof. Installation of a soil cover could significantly decrease water infiltration and contamination. If less water is infiltrating it will likely not have a negative effect on mine water quality (increasing TDS) as the salt content is controlled by mineral saturation rather than straightforward dilution;
- Static groundwater levels should be monitored as mentioned in Section 14 to ensure that any deviation of the groundwater flow from the idealised predictions is detected in time;
- The numerical model should be updated every two years by using the measured water ingress and water levels to re-calibrate and refine the impact predictive scenario;
- If it can be proven that the mining operation is indeed affecting the quantity of groundwater available to certain users, the affected parties may need to be compensated. This may be done through installation of additional boreholes for water supply purposes, or an alternative water supply; however, this should be assessed on an individual basis to determine the most appropriate solution for all affected;
- The monitoring results must be interpreted annually by a qualified hydrogeologist and the adequacy of the network should be assessed annually ensure compliance;
- The rehabilitated open pit should be free draining to reduce drainage into the pit;
- Boreholes should be drilled into the open pit so that the rate of flooding and water level recovery and quality can be established. Stage curves should be made which would aid in the management prior to the closure phase. The location of these boreholes can be established based on the coal floor elevations and should generally be placed in the deeper sections of the rehabilitated open pit;
- A detailed mine closure plan should be prepared during the operational phase, including a risk assessment, water resource impact prediction, etc.;
- An investigation on inter-mine flow should be commissioned to assess the likely changes to the various impacts;
- A numerical model should be developed for NCC area including and the historic and current mining activities. This consolidated model can then be used a management tool to assess and quantity impacts across the NCC area; and
- It is recommended that a comprehensive geochemical assessment be conducted. Geochemical samples should be collected and analysed annually. A geochemical

model should be performed to assess the effectiveness of potential mitigation measures. The model can then be updated every two years with the new data.

13.3 Post-Closure Phase

- Properly engineered decant containment or treatment solutions should be designed;
- Negotiate and obtain groundwater closure objectives approved by relevant stakeholders during the decommissioning phase of the project, based on the results of the monitoring information obtained during the construction and operational phases of the project, and through verification of the numerical model constructed for the project;
- Continue with the groundwater quality and groundwater level monitoring for a period of two to four years after mining ceases in order to establish post-closure groundwater level and quality trends. The monitoring information must be used to update, verify and recalibrate the predictive tools used during the study to increase the confidence in the closure objectives and management plans;
- Present the results of the monitoring programme to relevant authorities on an annual basis. The post-closure monitoring programme will be re-evaluated on an annual basis in consultation with relevant authorities; and
- Negotiate mine closure with relevant authorities based on the results of the groundwater monitoring undertaken, after the two- to four-year post-closure monitoring periods.
- Multiple-level monitoring boreholes must be constructed to monitor groundwater level behaviour in the backfilled pit. The results of the monitoring programme could be used to confirm/validate the predicted impacts on groundwater availability and quality after closure;
- Update existing predictive tools to verify long-term impacts on groundwater;
- Present the results to the authorities on an annual basis to determine compliance with the closure objectives;
- Implement as many closure measures, such as concurrent rehabilitation, during the operational phase, while conducting appropriate monitoring programmes to demonstrate actual performance of the various management actions during the life of mine;
- All mined areas should be flooded as soon as possible to bar oxygen from reacting with remaining pyrite;
- The final backfilled open pit topography should be engineered such that runoff is directed away from the open pit areas;
- A soil cover design study should be conducted to assess the likely closure cover for the open pits; and
- Audit the monitoring network annually.

14 Groundwater Monitoring Network

The groundwater monitoring network design should comply with the risk-based source-pathway-receptor principle. A groundwater-monitoring network should contain monitoring positions which can assess the groundwater status at certain areas. Both the impact on water quality and water quantity should be catered for in the monitoring system. The boreholes in the network should cover the following: contaminant sources, receptors and potential contaminant plumes. Furthermore, monitoring of the background water quality and levels is also required. Groundwater monitoring should be conducted to assess the following:

- The impact of mine dewatering on the surrounding aquifers. This will be achieved through monitoring of groundwater levels in the monitoring boreholes. If private boreholes are identified within the zone of impact on groundwater levels, these will be included in the monitoring programme;
- Groundwater inflow into the mine workings. This will be achieved through monitoring of groundwater levels in the monitoring boreholes as well as measuring water volumes pumped from mining areas;
- Groundwater quality trends. This will be achieved through sampling of the groundwater in the boreholes at the prescribed frequency; and
- The rate of groundwater recovery and the potential for decant after mining ceases. This can be achieved through measuring groundwater levels in the open pit workings. Stage curves will be drawn to assess the inflow into defunct workings.

Groundwater Monitoring should be undertaken according to the schedule presented in Table 14-1. The proposed monitoring network can be seen Table 14-1. It is envisaged that the frequency of monitoring remains on a quarterly basis.

Table 14-1: Groundwater Monitoring Programme

Monitoring position	Sampling interval	Water Quality Standards
Construction, Operational, Decommissioning and Post Closure Phases		
All monitoring boreholes	Quarterly: measuring the depth of groundwater levels	N/A
All monitoring boreholes	Quarterly: sampling for water quality analysis	South African Water Quality Guidelines: Domestic Use
Rainfall	Daily at the mine	N/A

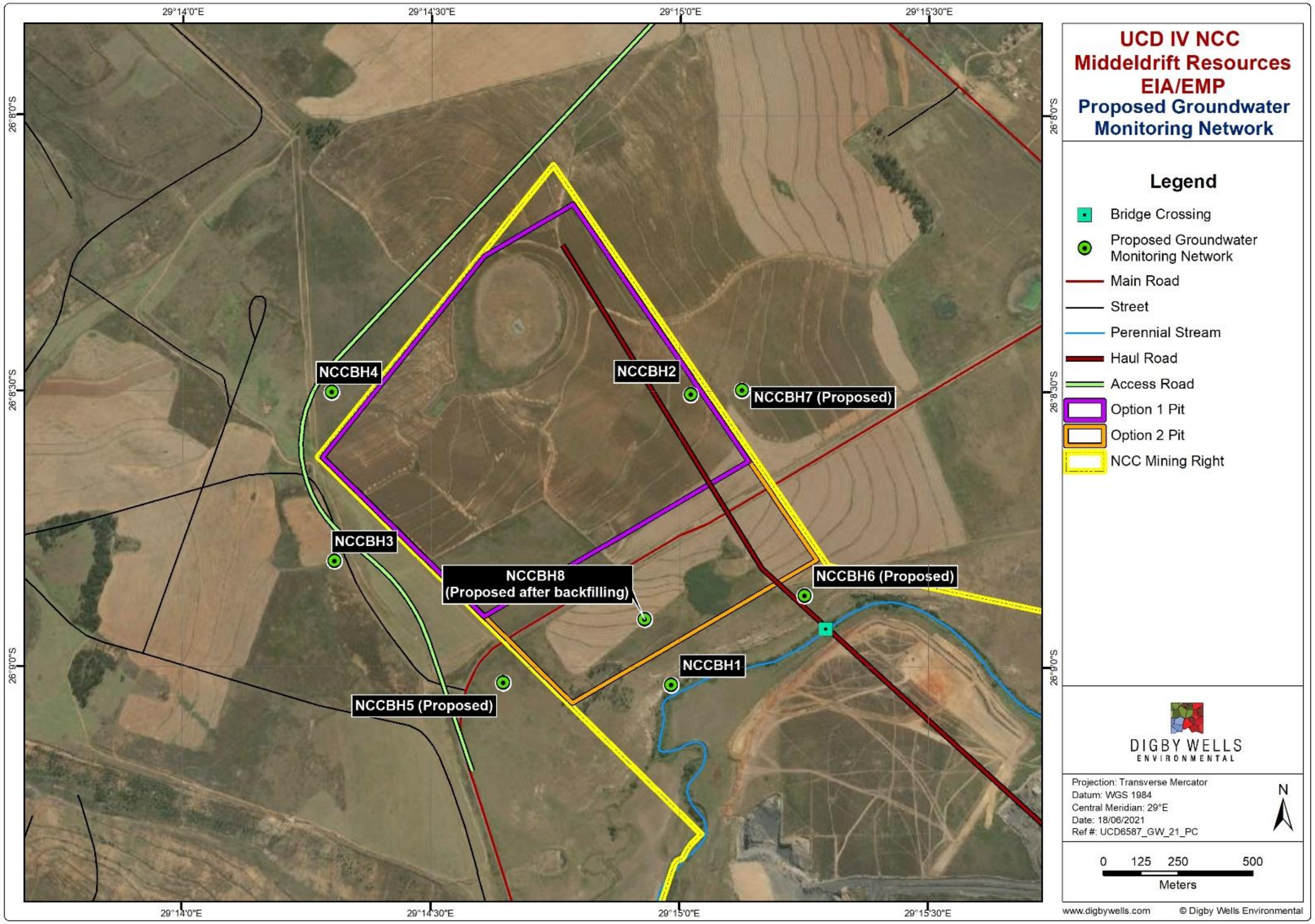


Figure 14-1: Proposed Groundwater Monitoring Network

15 Conclusions and recommendations

15.1 Conclusions

- *General:*
  - The area in which the proposed Middeldrift open pit mining is situated is already significantly impacted by adjacent mining activities to the north, west and south of Middeldrift as well as current open pit mining by Universal Coal of the Roodekop area on the southern side of the Steenkoolspruit;
  - The surrounding underground mining activities have already impacted on background groundwater levels in the direct vicinity of Middeldrift, as these mines are still being dewatered or have not been flooded yet;
  - Groundwater levels surrounding the proposed Middeldrift open pit are therefore reduced and were measured to be between approximately 40 – 50 meters below ground level (mbgl), with the exception of the riparian zone close to the Steenkoolspruit where groundwater levels are close to surface (approximately 5 – 10 mbgl);
  - Groundwater use in the vicinity of the proposed mining area is sparse and the closest groundwater users are approximately 1 200 m away from the proposed open pit;
  - Based on the most recent monitoring and hydrocensus data, background groundwater quality shows that the groundwater in the vicinity of Middeldrift is generally of good quality when compared to the South African Water Quality Guidelines (SAWQG). Some exceedances for sulphate, fluoride, iron and manganese were noted, where sulphate can be linked to the historic and current mining activities. The pH measured at a nearby spring was measured acidic during the hydrocensus;
  - For the purpose of this study, it was assumed that barrier pillars will remain between the existing underground mines and the proposed open pit and no inter-mine flow was taken into account; and
  - However, this assumption needs to be verified before mining commences; if connections with neighbouring mining areas will be established, groundwater inflows into the open pit may increase significantly.
- *Impacts:*
  - For the modelling of groundwater impacts, impacts of adjacent mining activities were taken into account. Groundwater levels in the newly drilled boreholes, existing monitoring boreholes and hydrocensus boreholes were used to calibrate the model;

- For the impact assessment, it has been assumed that the underground mine voids in the vicinity of and neighbouring Middeldrift will remain dewatered during the Middeldrift operational phase. This is an acceptable assumption as underground mines are currently not flooded, the proposed Life of Mine (LoM) for Middeldrift is relatively short and mining at Middeldrift is expected to commence in 2022. However, it has been anticipated that these mining areas are flooded after closure of Middeldrift. This is a worst-case assumption with regards to post-closure contaminant plume movement and decant;
- Only negligible impacts are expected for the construction phase due to limited site infrastructure and no mine waste facilities;
- Included were two optionsfor mining: option 1 is a smaller open pit with a LoM of 11 years, option 2 is a larger open pit with a LoM of 14 years;
- Local groundwater levels are drawn down due to adjacent underground mining, and inflows during the operational phase will be relatively low. It is recommended that mining at Middeldrift takes place as soon as possible to keep to these reduced inflows, and to reduce the risk of inter-mine flow;
- The impact on groundwater levels and resource during the operational phase is expected to be minor. It is not expected that any groundwater users or springs will be impacted upon. Baseflow in the Steenkoolspruit is expected to be reduced by 34% for option 1 and 41% for option 2, and there will be a cumulative impact on the baseflow by the existing and proposed mining at Roodekop. This baseflow will increase again post-closure to near pre-mining volumes;
- Contaminant plume movement is considered a moderate impact for the post-closure phase and can be limited to a certain extent by mitigation measures, such as proper rehabilitation and soil cover placements;
- Decant is predicted post-closure, for a worst-case scenario in which the adjacent underground voids will be flooded, allowing the backfilled opencast to flood and decant. However, as this is dependant on other mining activities, risks for decant from the various mining areas should be dealt with on a regional scale; and
- Decant from Middeldrift is considered as a moderately significant impact due to the relatively small scale of the activities. Taking into account mitigation options, such as a decant abstraction borehole, this would reduce decant generation and would lower the significance of this impact to minor.

15.2 Recommendations

The impacts above as determined are as expected based the best knowledge of the current site conditions. However, to improve the accuracy of this study, the following *recommendations* are made in order of importance:

- Delineations of existing mining areas should be confirmed before mining commences to avoid the creation of direct flow paths and significant inter-mine flows between existing underground voids and the proposed Middeldrift open pit;
- Mine plans and schedules for the adjacent underground mines should be obtained to understand when the end of LoM will be for each operation, and when flooding of the voids will take place;
- A numerical flow and contaminant transport model should be developed for region, including historic, current, and planned mining activities. This consolidated model can then be used as a management tool to assess and quantify the regional impacts;
- A feasibility study for a pit lake/final void or constructed decant point is recommended to assess the impact and costs of such mitigation measures. This study should be based on a post-closure landform design. This could reduce the post-closure impacts, as well as the required volume of water to be treated post-closure.
- Kinetic leaching tests and geochemical modelling should be performed on coal and backfill material to obtain trends and variability in leachate and decant quality over time, as only static leach tests were used as input for post-closure seepage quality in this assessment;
- The numerical groundwater model should be updated and re-calibrated every two years to reflect the operational and post-rehabilitation conditions and most recent groundwater levels; it should also be updated as new hydrogeological or geochemical information becomes available, or when there are significant changes made to the mine schedule;
- Decant volumes should be re-calculated every two years using numerical models and spreadsheet calculations, and should be based on the rehabilitation design of the open pit;
- Recharge estimates to the backfilled pit should be updated once when backfilling is complete, based on the actual characteristics of the backfill and capping to improve the accuracy of the decant volumes and time-to-decant;
- A mine water decant action plan should be developed to address the impacts associated with decant, seepage and base flow salt loads for the operational and post-closure impacts;
- A surface water blending model should be conducted to assess the risk associated with the salt load contribution to the base flow;

- The groundwater monitoring network should be updated based on the existing and proposed monitoring positions as per this report; and
- A monitoring database should be established that contains all historic and future groundwater monitoring data.

16 Reasoned Specialist Opinion

Provided all the recommended mitigations, management measures and studies are implemented, there is no reason why the mining of the proposed project should not proceed from a hydrogeological point of view.

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Appendix A: Monitoring Borehole Logs

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Appendix B: Hydrocensus Survey