Submitted to: Uis Tin Mining Company (Pty) Ltd.
Attention: Mr Efraim Tourob
4tth Avenue East, Number 1, Uis
P O Box 30
Uis, Namibia.

REPORT:

UIS TIN MINE – ESIA REPORT FOR THE STAGE II EXPANSION OF THE PILOT TIN PROCESSING PLANT INCLUDING A BULK SAMPLE, SORTING AND TESTING FACILITY ON ML 134

PROJECT NUMBER: ECC-84-284-REP-14-D

REPORT VERSION: REV 02

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Project Name:	Uis Tin Mine – ESIA report for the Stage II expansion of the pilot tin processing plant including a bulk sample, sorting and testing facility on ML 134
Client Company Name:	Uis Tin Mining Company (Pty) Ltd.
Client Name:	Mr Efraim Tourob
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Authors	Jessica Bezuidenhout
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ENVIRONMENTAL COMPLIANCE CONSULTANCY CONTACT DETAILS:

We welcome any enquiries regarding this document and its content. Please contact:

Environmental Compliance Consultancy
PO Box 91193, Klein Windhoek, Namibia
Tel: +264 81 669 7608
Email: info@eccenvironmental.com

DISCLAIMER

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EXECUTIVE SUMMARY

Environmental Compliance Consultancy (Pty) Ltd (ECC) has been contracted by Uis Tin Mining Company (Pty) Ltd., a subsidiary of Andrada Mining (Pty) Ltd. to undertake an environmental and social impact assessment (ESIA). Uis Tin Mining Company (Pty) Ltd. is the Proponent for the proposed Project.

ECC has conducted an ESIA for the proposed amendment to the stage II expansion of the pilot tin processing plant, the construction and operation of a new bulk sample sorting and testing facility, and continued mining activities on Mining Licence (ML) 134 in the Erongo Region, Namibia. The proposed Project will be referred to as the “Uis Stage II Project” or the “Project” herein.

In terms of the Namibian Environmental Management Act, 2007 and its regulations, the Ministry of Mines and Energy (MME) is the competent authority for the proposed Project. Mining operations trigger listed activities in terms of the Act, and as such, require an environmental clearance certificate.

SCREENING PHASE

A high-level ESIA formed part of the company’s published preliminary economic assessment (PEA) and was incorporated into the screening phase. Alternatives considered on the Project were limited to technological designs of the comminution and processing machinery, and placement within the already disturbed footprint. Water supply alternatives were also considered.

The screening phase determined that the most likely potential environmental and social impacts could include:

- Surface and groundwater impacts
- Impacts on road users
- Visual impacts affecting the sense of place
- Impacts on air quality
- Social impacts during construction, operations, and post-closure
- Habitat alteration and impacts on biodiversity.

SCOPING PHASE

The objective of the scoping Phase 1 is to obtain an understanding of the biophysical and socioeconomic environment in which the Project is located. It also provides an opportunity for the public to have input into the scope of the assessment. The technical inputs combined with the inputs from the interested and affected parties (I&APs) led to the development of the

Terms of Reference (ToR) for the assessment phase. The following sources of information were used during the preparation of the scoping report and assessment process:

- Desktop and literature research
- Site visits by ECC and specialists
- Environmental monitoring data
- Specialist baseline studies, including:
    - Acid-base accounting (ongoing geochemical study)
    - Air quality
    - Biodiversity study
    - Heritage and archaeology study
    - Noise
    - Road traffic study
    - Socioeconomic baseline
    - Soil sampling and analysis (ongoing study)
    - Surface and groundwater studies (ongoing study)
    - Visual impacts on sense of place.

TERMS OF REFERENCE

The ToR within the scoping report proposed the assessment phase will cover the following:

- Acid mine drainage impact assessment
- Surface and groundwater impact assessment
- Biodiversity impact assessment
- Noise impact assessment
- Air quality impact assessment
- Traffic impact assessment
- Visual impact assessment
- Socioeconomic impact assessment
- Heritage impact assessment
- Blast and vibration assessment.

The methodology used for assessing impacts was described in the scoping report and is set out in chapter 6 of this assessment report. A hierarchical decision-making process was followed, to prevent or eliminate, reduce, or offset, mitigate, or manage potential impacts. The draft scoping report and draft environmental management plan (EMP) were provided to the public for review (23 February to 9 March 2022) prior to submission to the competent authority, including MME and MEFT on the 11th of March 2022.

The next stage of the assessment was to undertake the impact assessment. All I&AP comments were responded to, either by providing an explanation or further information in the response table, or by signposting where information exists, or where new information has been included in the ESIA report or appendices. The comments and concerns were considered along with the technical information for completing the assessment and developing mitigation for inclusion in the environmental and social management plan (ESMP).

The draft ESIA report and appendices were available to all stakeholders, and all I&APs were informed of the reports available for review.

This final report and appendices will be formally submitted to the competent authority, first the MME and then to the MEFT as part of the application for an environmental clearance certificate for the proposed Project. The process completed is shown in Figure 1.

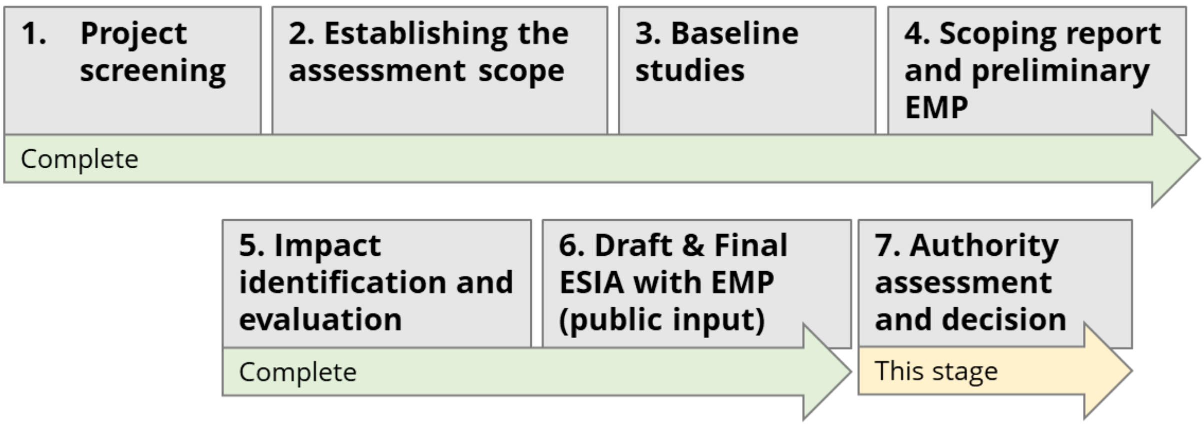

Figure 1 – Simplified Namibian ESIA process noting UTMC progress

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ABBREVIATIONS

ABBREVIATION	DESCRIPTION
APP	Air pressure pulse
CBNRM	Community based natural resource management
CC	Close Corporation
CEO	Chief Executive Officer
CIA	Cumulative impact assessment
COVID	Coronavirus
COVID-19	Coronavirus 2019
CUPB	Cape Cross–Uis Pegmatite Belt
CWC	Clean water channel
dBA	Decibels
DEA	Directorate of Environmental Assessment
DTM	Digital terrain model
DMS	Dense medium separation
DWA	Department Water Affairs
EAP	Environmental assessment practitioner
ECC	Environmental Compliance Consultancy
ECC	Environmental clearance certificate
EHS	Environmental health and safety
EIA	Environmental impact assessment
EMA	Environmental Management Act
EMP	Environmental management plan
EPLs	Exclusive prospecting licences
ESIA	Environmental and social impact assessment
g/t	Grams per tonne
GDP	Gross domestic product
GG	Government gazette
GN	Government notice
GRP	Gas release pulse
HCV	High conservation value
HDPE	High density polyethylene
HIV/AIDS	Human immunodeficiency virus / acquired immunodeficiency syndrome
I&APs	Interested and affected parties
IFC	International Finance Corporation
ITS	ITS Global - traffic engineering consultants
km	Kilometres
km/h	Kilometres per hour
km2	kilometres squared

ABBREVIATION	DESCRIPTION
kV	kilovolts
kW	kilowatt
LOM	life of mine
Ltd	limited
m	metre
m/s	metre per second
m3	cubic metres
m3/day	cubic metres per day
Ma	million years ago
masl	metres above sea level
MAWLR	Ministry of Agriculture, Water and Land Reform
MEFT	Ministry of Environment, Forestry and Tourism
mg/m2/day	milligrams per metres squared per day
ML	mining licence
mm	millimetre
Mm3	million cubic metres
MME	Ministry of Mines and Energy (competent authority)
MoWT	Ministry of Works and Transport
Mt	million tonnes per annum
Mtpa	million tonnes per annum
MW	million watts
MSF	metallurgical support facility
N$	Namibian dollar
Na	sodium
NBRI	National Botanical Research Institute
NDP	National Development Plan
NHC	National Heritage Council
NSR	noise sensitive receptor
NT	near-threatened
OECD	Organisation for Economic Co-operation and Development
PCP	pollution control pond
pH	acidity alkalinity unit
PM	particulate matter
PM10	particulate matter with an aerodynamic diameter of less than 10 µm (thoracic particles)
PM2.5	particulate matter with an aerodynamic diameter of less than 2.5 µm (respirable particles)
POI	points of interest

ABBREVIATION	DESCRIPTION
Project	Uis Tin Mine Stage II Project
Proponent	Uis Tin Mining Company (Pty) Ltd
Pty	propriety
Reg	registration
ROM	run of mine
RPP	rock pressure pulse
RWP	return water pond
t	tonnes
TB	tuberculosis
ToR	terms of reference
Tph	tonnes per hour
TSF	tailings storage facility
WHO	World Health Organisation
WRD	waste rock dump
Zn	zinc
μS/cm	microsiemens per cm

1 INTRODUCTION

1.1 COMPANY BACKGROUND

Environmental Compliance Consultancy (ECC) has been contracted by Uis Tin Mining Company (Pty) Ltd (UTMC), the Proponent, a subsidiary of Andrada Mining Limited to undertake an environmental and social impact assessment (ESIA) and an environmental management plan (EMP) in terms of the Environmental Management Act, No 7 of 2007 and its regulations of 2012 for target expansion interventions at UTMC.

The Uis Tin Mine is located in the town of Uis, Erongo Region, Namibia. The mine can be accessed by the C36 road from Omaruru, the C35 from Henties Bay or the C35 from Khorixas. Refer to Figure 2 for the project location.

Andrada Mining has a portfolio of tin assets in Namibia. UTMC, the Namibian registered subsidiary, intends to undertake mechanical and process flow upgrades to its existing tin extraction systems which would allow the mine to produce tantalum as a by-product of the existing process. UTMC also intends to build a bulk sample processing facility adjacent to the existing processing plant at a later stage during the life of operations. The purpose of the bulk sample processing facility is to undertake metallurgical test work on the material from the existing mine pits, as well as from external areas where exploration work is being undertaken to assess the process required to extract minerals from the ore(s). Extraction of minerals such as tin, tungsten, tantalum, lithium, copper, silver, and gold will be assessed. Due to the use of hazardous chemicals like hydrofluoric acid, sulphuric acid, and caustic soda in the flotation circuit of the bulk sample processing facility, a waste neutralisation plant will be installed within the bulk sampling, sorting, and testing facility. Acid-bearing waste products (liquid and solid form) will be neutralised before final discard on either the existing waste rock dumps or disposal at the Walvis Bay hazardous waste disposal site via trucks. Monitoring measures (kinetic leach tests) will be implemented at this plant to ensure the final discard material meets safety and environmental standards (inert and unreactive) before final disposal.

The addition of the lithium flotation circuit will undergo an environmental impact assessment amendment application before its addition to the bulk sampling, sorting, and testing facility.

The proposed Project upgrades to the current pilot plant's processing and supporting infrastructure will expand production from the current 80 tons per hour (tph) of tin concentrate in Stage I to 120 tph in Stage II.

Ore (cassiterite) will continue to be extracted from the current two open pit mines, which will supply the Stage II operations within the project area of ML 134. Petalite bearing ore will be separated from overburden, sorted and prepared in the newly proposed bulk sampling, sorting, and testing facility. Open-pit V1 will continue to be mined and extended in a southerly direction eventually being merged with Open-pit V2.

The additional changes associated with this assessment and project changes include:

- Upgrades to the existing sewage effluent water collection and treatment system
- Building a clean stormwater channel (CWC) and berm around the plant for water re-use in the processing circuit
- An upgrade of the existing settling and evaporation ponds
- Increased water supply (from 75 000 to 150 000 cubic meters per year), now part of the amended abstraction permit.
- New, but limited in spatial extent, haul and access roads will be constructed to access the bulk sampling, sorting, and testing facility.

These upgrades are designed to consistently achieve a targeted tin recovery of 64% and they form an integral part of the 20-year life of mine (LOM).

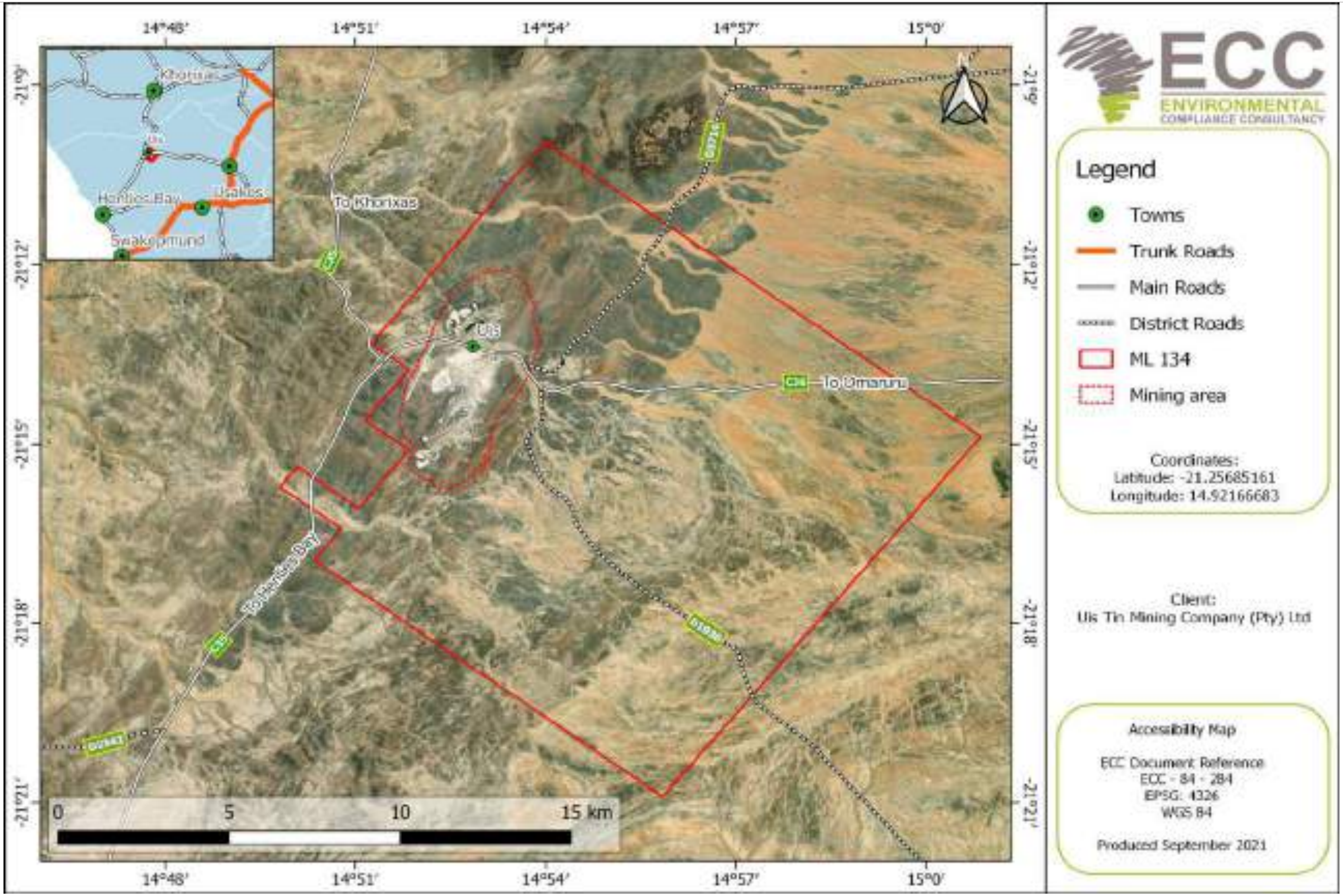

Figure 2 – A map showing the regional location of the Uis tin mining area and ML 134 and access options

1.2 REPORT PURPOSE

The environmental and social impact assessment (ESIA) has been conducted in terms of the Namibian Environmental Management Act, 2007 and its regulations. This report presents the findings of the assessment, including inputs from stakeholders. In addition to describing the prescribed ESIA process, the report describes the baseline biophysical and socioeconomic environments, provides a project description, provides findings from the assessment phase, and presents a preliminary environmental and social management plan (ESMP) (Appendix A).

The scope of the assessment was determined by undertaking a preliminary assessment of the proposed Project against the receiving environment, obtained through a desktop review, available site-specific literature, monitoring data, site reports, and specialist studies.

The scoping report and appendices were submitted to the public for review (23 February – 9 March 2022), and inputs on the impacts and the related ESIA terms of reference were sought. After the public review period the final scoping report (with public input) was submitted to the Ministry of Mines and Energy (MME) as the competent authority for the Project, and to the Ministry of Environment, Forestry, and Tourism (MEFT) – Directorate of Environmental Affairs (DEA) for their review. The MEFT awarded environmental clearance for the project on the scoping report and issued an environmental clearance certificate on the 8th August 2022.

An addendum report containing the details of the proposed material changes for the project was submitted to the MEFT on the 9th of September 2022. The addendum report supplied additional project details to supplement the scoping report, and was produced to update and confirm the scope of this assessment. The scope of this assessment excludes the construction and operation of the proposed lithium flotation circuit. This will be covered in an assessment once all details, test work, and specialist investigations are finalised.

Once completed, the ESIA report will be shared with registered I&APs for a 14-day review period. The final report will then be sent to the competent authorities, MME and MEFT, for review and a record of decision. The report comprises nine chapters covering the project introduction, ESIA approach, legal environmental requirements, potential impact assessment, screening and scoping results, impact evaluation methodology, impact assessment findings, conclusion, and bibliography.

1.3 THE PROPONENT OF THE PROPOSED PROJECT

The Uis Tin Mining Company is the Proponent for the proposed Project. The Proponent holds the rights to the mining licence 134 located in Uis, Erongo Region, Namibia. The Proponents' details are provided in Table 1.

Table 1 – Proponent's details

COMPANY REPRESENTATIVE:	CONTACT DETAILS:
Mr. Efraim Tourob	Uis Tin Mining Company (Pty) Ltd: 4th Avenue East, Number 1, Uis, PO Box 30, Uis efraim.tourob@Andradamining.com +264 (64) 504 404

1.4 ENVIRONMENTAL AND SOCIAL ASSESSMENT PRACTITIONER

Environmental Compliance Consultancy (Pty) Ltd (ECC) (CRN 2022/0593) has prepared this ESIA report and the preliminary ESMP on behalf of the Proponent.

This report was authored by employees of ECC (Appendix C), who have neither material interest in the outcome of this report, nor any interest that could be reasonably regarded as being capable of affecting their independence in the preparation of this report. ECC is independent from the Proponent and has no vested or financial interest in the Project, except for fair remuneration for professional fees rendered based upon agreed commercial rates. Payment of these fees is in no way contingent on the results of this report or the assessment, or a record of decision issued by Government. No member or employee of ECC is, or is intending to be, a director, officer, or any other direct employee of Uis Tin Mining Company (Pty) Ltd. No member or employee of ECC has, or has had, any shareholding in the Uis Tin Mining Company (Pty) Ltd.

All compliance and regulatory requirements regarding this report should be forwarded by email or posted to the following address:

Environmental Compliance Consultancy
PO Box 91193, Klein Windhoek, Namibia
Tel: +264 81 669 7608
Email: info@eccenvironmental.com

1.5 ENVIRONMENTAL REQUIREMENTS

The Environmental Management Act, 2007, and its regulations stipulate that an environmental clearance certificate is required before undertaking any of the listed activities that are identified in the Act and its regulations. Potential listed activities triggered by the Project are provided in Table 2.

Table 2 – Activities potentially triggered by the Project

Source: Environmental Management Act, 2007, and its regulations

Listed activity	As defined by the regulations of the Act	Relevance to the project
Energy generation, transmission, and storage activities	The construction of facilities for: (1a) The generation of electricity. (1b) The transmission and supply of electricity.	External diesel generators are in use on site as emergency back-up power supply sources to skeleton operations in the event of a power failure. An existing 66 kilovolt powerline and associated infrastructure located within the Accessory Work Permit area of the ML will continue to be used. No upgrades are needed for the proposed Project.
Waste management, treatment, handling, and disposal activities	2.1 The construction of facilities for waste sites, and the treatment and disposal of waste. 2.2 Any activity entailing a scheduled process referred to in the Atmospheric Pollution Prevention Ordinance Act, 1976. 2.3 The importing, processing, use and recycling, temporary storage, transit, or exporting, of waste.	The following fall within provision 2.2: Any activity entailing a scheduled process referred to in the Atmospheric Pollution Prevention Ordinance, 1976. o Mining activities generate dust, monitored monthly. o Potential for noxious gas generation and emission. The following aspects fall within this provision: (2.3). The import, processing, use and recycling, temporary storage, transit, or export of waste. A BioMite sewage system has recently replaced the old Clarus Fusion Wastewater Treatment Plant, or WWTP sewage effluent water collection and treatment system. Sewage waste is pumped out of septic tanks onsite every quarter, or when required, by a local contractor and disposed of at the local evaporation ponds.

Listed activity	As defined by the regulations of the Act	Relevance to the project
		A salvage yard collection and storage facility is in use within the area of the facilities. Overburden and processing plant waste minerals (>6mm) are transported and co-disposed on the WRD site located within the mining licence footprint. Solid and hazardous waste collection points are in use on the site. Hazardous waste is disposed of at an approved facility, or in an approved manner as per permitting.
Mining and quarrying activities	3.1 The construction of facilities for any process or activities that require a licence, right or other form of authorisation, and the renewal of a licence, right or other form of authorisation, in terms of the Minerals (Prospecting and Mining) Act, 1992. 3.2 Other forms of mining or extraction of any natural resources, whether regulated by law or not. 3.3 Resource extraction, manipulation, conservation, and related activities.	The current brownfields operations are permitted under an approved mining licence (ML134). The resource, tin and tantalum ore within pegmatite, is mined and extracted within the processing plant to produce tin and tantalum concentrates. The process crushes the ore and separates the denser tin and related minerals (tantalum) from the pegmatite, primarily through gravity type separation. No chemicals are used in the separation process, other than ferrosilicon to enhance dense media separation; the FeSi medium is recovered and reused. The bulk sample, sorting and testing facility will utilise sensors containing radioactive sources to sort ore and chemical reagents

Listed activity	As defined by the regulations of the Act	Relevance to the project
		(hydrofluoric, sulphuric acid and caustic soda) in the petalite lithium concentrator plant.
Forestry activities	4. The clearance of forest areas, deforestation, afforestation, timber harvesting, or any other related activity that requires authorisation in terms of the Forest Act, 2001 (No. 12 of 2001) or any other law.	Vegetation clearing will be required for site construction and infrastructure establishment. Necessary licences and permits will be obtained for the clearing of protected species Before operations, vegetation clearing will be required. Vegetation may also be removed as the project develops
Water resource developments	8.1 The abstraction of ground or surface water for industrial or commercial purposes. 8.2 The abstraction of groundwater at a volume exceeding the threshold authorised in terms of the law relating to water resources. 8.5 Construction of dams, reservoirs, levees, and weirs. 8.6 Construction of industrial and domestic wastewater treatment plants and related pipeline systems. 8.8 Construction and other activities in watercourses within flood lines. 8.9 Construction and other activities within a catchment area.	- Mining operations will continue to utilize groundwater and surface water sources for their processing requirements, and dust suppression. Potable water will continue to be sourced from NamWater. - Currently, there is an abstraction permit that allows for 150 000 cubic meters abstraction threshold per year valid for three years. This was increased from the 75 000 cubic meters authorised volume to supply production needs. - The Project will entail the installation of a new clean water channel (CWC) stormwater channel and berm around the processing plant as well as an upgrade of the existing settling and water return ponds, all to increase the availability of recycle and reusable water. - The Project falls within the Ugab catchment area.
Hazardous substance treatment,	9.1 The manufacturing, storage, handling, or processing of hazardous substance defined in the Hazardous Substances Ordinance, 1974.	The mining operations and proposed process plant triggers this activity, as both fuel and hazardous substances are required for mining and processing.

Listed activity	As defined by the regulations of the Act	Relevance to the project
handling, and storage	9.2 Any process or activity that requires a permit, licence, or other form of authorisation, or the modification of, or changes to, existing facilities for any process or activity that requires amendment of an existing permit, licence or authorisation, or which requires a new permit, licence or authorisation in terms of governing the generation or release of emissions, pollution, effluent, or waste. 9.4 The storage and handling of dangerous goods, including petrol, diesel, liquid petroleum, gas, or paraffin, in containers with the combined capacity of more than 30 cubic meters at one location.	Bulk fuel is stored onsite for refuelling the mining fleet and for backup power from onsite generators. Consumer installation certificates are required for bulk fuel storage and dispensing. Hazardous reagents will be used within the petalite lithium beneficiation plant, in addition to the current fuels and lubricants and related maintenance and consumable hydrocarbons and petrochemical for operating and maintaining the fleet. Licences will be obtained for hazardous substances and their storage and use on site. The relevant certificate to erect a building that will store and use hazardous chemicals (i.e., Hydrofluoric and sulphuric acid) will also be obtained.

2APPROACH TO THE ASSESSMENT

2.1 PURPOSE AND SCOPE OF THE ASSESSMENT

The aim of this assessment is to provide a summary of the project, the environmental and social baseline conditions, the summary of assessment process and methodology, legal requirements, a list of aspects and specialists investigations, a determination of which impacts are likely to be significant, mitigation required to management the potential impacts, and an environmental and social management plan.

2.2 THE ASSESSMENT PROCESS

The ESIA methodology applied to this assessment has been developed using the International Finance Corporation (IFC) standards and models, in particular Performance Standard 1: Assessment and management of environmental and social risks and impacts (International Finance Corporation, 2012 and 2017); Namibian Draft Procedures and Guidance for EIA and EMP (Republic of Namibia, 2008); international and national best practice guidelines; and combined relevant ESIA experience.

This assessment is a formal process. The potential effects that the Project will have on the biophysical, social, and economic environments are identified, assessed, and documented so that the breadth and significance of potential impacts can be taken into account when considering a record of decision for the proposed Project.

Final mitigation measures and recommendations are based on the cumulative experience of the consulting team (including the contracted specialists) and the client, taking into consideration the potential environmental and social impacts. The process followed, through the basic assessment, is illustrated in Figure 3 and is detailed further in the following sections.

1. Project screening

Complete

The first stages in the ESIA process are to undertake a screening exercise to determine whether the Project triggers listed activities under the Environmental Management Act, 2007, and its regulations. The screening phase of the Project is a preliminary analysis, in order to determine ways in which the Project might interact with the biophysical, social, and economic environments.

Stakeholder engagement:
- Registration of the project
- Preparation of the BID

2. Establishing the assessment scope

Complete

Where an ESIA is required, the second stage is to scope the assessment. The main aim of this stage is to determine which impacts are likely to be significant; to scope the available data and any gaps that need to be filled; to determine the spatial and temporal scope; and to identify the assessment methodology.

The scope of this assessment was determined through undertaking a preliminary assessment of the proposed Project against the receiving environment. Feedback from consultation with the public and the Proponent informs this process. The following environmental and social topics were scoped into the assessment, as there was the potential for significant impacts to occur. Impacts that are identified as potentially significant during the screening and scoping phase are taken forward for further assessment in the ESIA process. These are:

BIOPHYSICAL ENVIRONMENT
- Noise and air quality, including dust emissions
- Surface and ground water
- Heritage and culture
- Biodiversity
- Soils

SOCIAL ENVIRONMENT
- Socio-economic
- Air quality
- Traffic
- Occupational health and safety
- Ground vibration and fly rock from blasting
- Heritage and archaeology
- Noise disturbance assessment
- Visual and sense of place

The following topics were scoped out of the ESIA, and they are therefore not discussed further in this report.
- An assessment of safety impacts or risks associated with exploration are not included within the scope of this assessment and will be addressed by the Proponent in a site-specific safety management plan.

3. Baseline studies

Complete

A robust baseline is required, in order to provide a reference point against which any future changes associated with a Project can be assessed, and to allow suitable mitigation and monitoring to be identified.

The project area has been studied extensively from 2019 – 2022 utilising various specialist works for various purposes. This literature was available to be referenced. The Project site-specific area has been studied as part of the ESIA process, and the following has been conducted as part of this assessment:
- Desktop studies
- Consultation with stakeholders
- Specialist studies

The environmental and social baselines are provided in the scoping study.

4. Draft scoping report and EMP

Complete

The scoping report documents the findings of the current process and provides stakeholders with an opportunity to comment and continue the consultation that forms part of the environmental assessment. The EMP provides measures to manage the environmental and social impacts of the proposed Project, and outlines the specific roles and responsibilities required in order to fulfil the management plan.

This scoping report focuses on describing the ESIA process, project description, baseline description and Terms of Reference for the assessment phase.

This report was issued to stakeholders and I&APs for consultation, for a period of 14 days, meeting the mandatory requirement as set out in the Environmental Management Act, Act 7 of 2007. The aim of this stage is to ensure that all stakeholders and I&APs have an opportunity to provide comments on the assessment process and to register their concerns, if any.

5. Impact identification and evaluation

Complete

The key stage of the ESIA process is the impact identification and evaluation stage. This stage is the process of bringing together Project characteristics with the baseline environmental characteristics and ensuring that all potentially significant environmental and social impacts are identified and assessed. It is an iterative process that commences at Project inception and ends with the final design and Project implementation. The impact identification and evaluation stages will be updated in the assessment phase.

The final design of the proposed Project will be assessed, along with alternatives that were considered during the design process in accordance with the Environmental Management Act, No 7 of 2007. Section 6 in this report sets out the assessment methodology to be used to assess the Project against the environmental and social baselines that would be affected.

6. Final EIA and EMP

This Stage

All comments received during the I&AP public review period will be collated in an addendum report, which will accompany this scoping report when submitted to the MEFT: DEA. All comments will be responded to, either through providing an explanation or further information in the response table, or by signposting where information exists, or where new information has been included in the ESIA report or appendices. Comments will be considered and where they are deemed to be material to the decision-making, or might enhance the ESIA, they will be incorporated.

The final ESIA report, appendices and the addendum report will be available to all stakeholders and all I&APs will be informed of its availability for review period of 14 days.

The ESIA report, appendices and addendum will be formally submitted to the competent authority (MME), the MEFT: DEA and MFMR as part of the application for an environmental clearance certificate.

7. Authority assessment and decision

Next Step

The Environmental Commissioner, in consultation with other relevant authorities, will assess if the findings of the ESIA presented in the report are acceptable. If deemed acceptable, the Environmental Commissioner will revert to the Proponent with a record of decision and recommendations.

8. Monitoring and auditing

Future Stage

In addition to the EMP being implemented by the Proponent, a monitoring strategy and audit procedure will be determined by the Proponent and competent authority. This will ensure key environmental receptors are monitored over time to establish any significant changes from the baseline environmental conditions, caused by Project activities

Figure 3 – The ESIA process approach – Project screening to post-approval auditing

2.3 STUDY AREA

This ESIA study area has been defined according to the geographic scope of the receiving environment, and potential impacts that could arise because of the proposed Project within that area. The study area encompasses the interior of ML 134, the Uis townlands, the surface, and groundwater resources, in and outbound traffic infrastructure, and the general mining area's spatial footprint. The study area is presented in Figure 4 and Figure 5. The study area extends beyond the mining licence boundary and includes the nearby receptors such as sensitive receptors for each study area and parts of the Uis town.

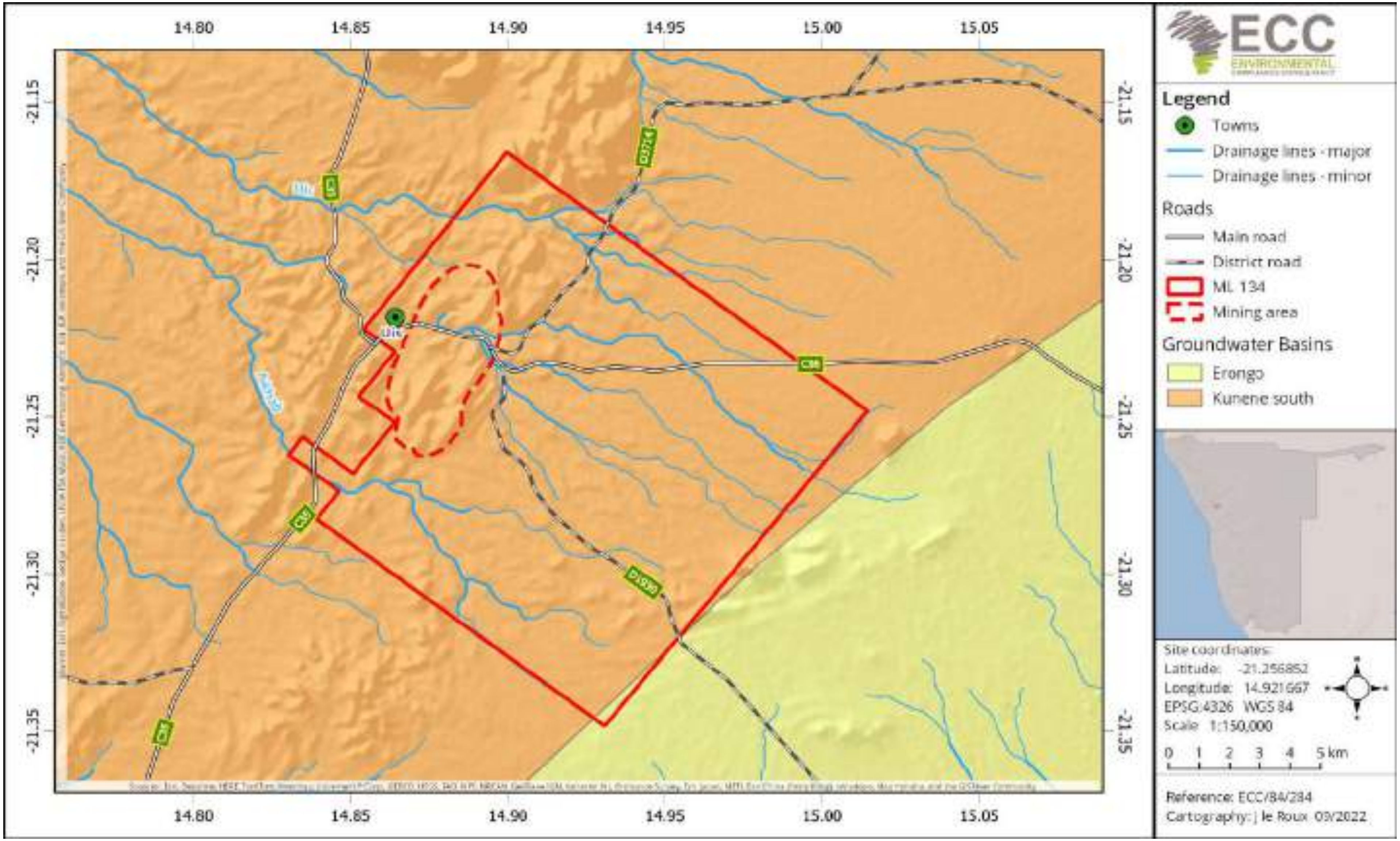

Figure 4 – ESIA study area, linear infrastructure, and regional setting

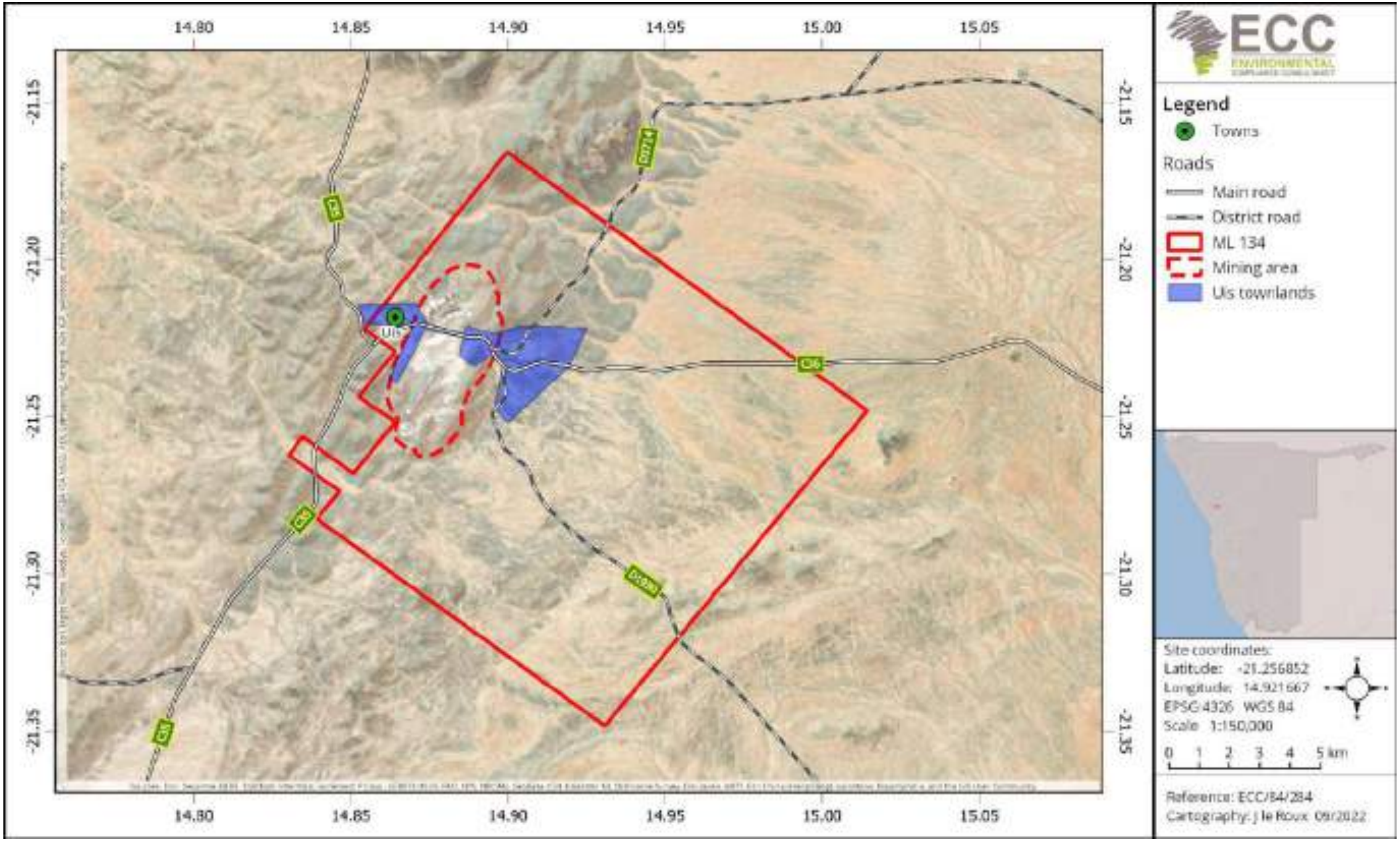

Figure 5 - Mining area, mining licence and townlands

2.4 PUBLIC CONSULTATION

Public participation and consultation is a requirement stipulated in Section 21 of the Regulations of the Environmental Management Act, 2007, for a project that requires an environmental clearance certificate. Consultation is a compulsory and critical component of the ESIA process for achieving transparent decision-making and can provide many benefits. Consultation is ongoing during the ESIA process. The objectives of the public participation and consultation process are to:

- Provide information on the Project, and introduce the overall Project concept and plan in the form of a background information document (BID) and where material changes are added to a project present these in an addendum report;
- Determine the relevant government, regional and local regulating authorities;
- Listen to and understand community issues, record concerns, and questions;
- Explain the process of the ESIA and timeframes involved, and
- Establish a platform for ongoing consultation.

2.4.1 IDENTIFICATION OF KEY STAKEHOLDERS AND INTERESTED OR AFFECTED PARTIES

A stakeholder mapping exercise was undertaken during the scoping phase to identify individual or groups of stakeholders, and the method in which they were engaged during the ESIA process. Stakeholders were approached through direct communication (letters and phone calls), the national press, site notices, or directly by email. The list of stakeholders is included in Appendix B.

A summarised list of stakeholders that were engaged during the public consultation process is given below:

- Directly and indirectly affected landholders
- The general public with an interest in the Project
- Ministry of Environment, Forestry and Tourism (MEFT)
- Ministry of Agriculture, Water and Land Reform (MAWLR)
- Ministry of Mines and Energy (MME)
- Ministry of Works and Transport (MWT) and the Roads Authority
- Ministry of Health and Social Services
- Erongo Regional Council
- Town residents and business owners
- Uis Village Council
- The settlement development committee
- Uis Mining Company Management structure
- Okombahe Traditional Authority
- NamWater and NamPower.

Appendix B provides a list of interested and affected parties, evidence of consultation, including the minutes of public meetings, advertisements in two national newspapers, and a summary of the comments or questions raised by the public. A summary of the key concerns raised during the consultation process is provided in section 2.1.2. A map of the identified stakeholders for the mining licence is illustrated in Figure 6.

The draft ESIA was submitted to the competent authority and I&APs for public review for a period of 14 days from 30 May 2023 to the 13 June 2023. No additional comments or input were received from the public.

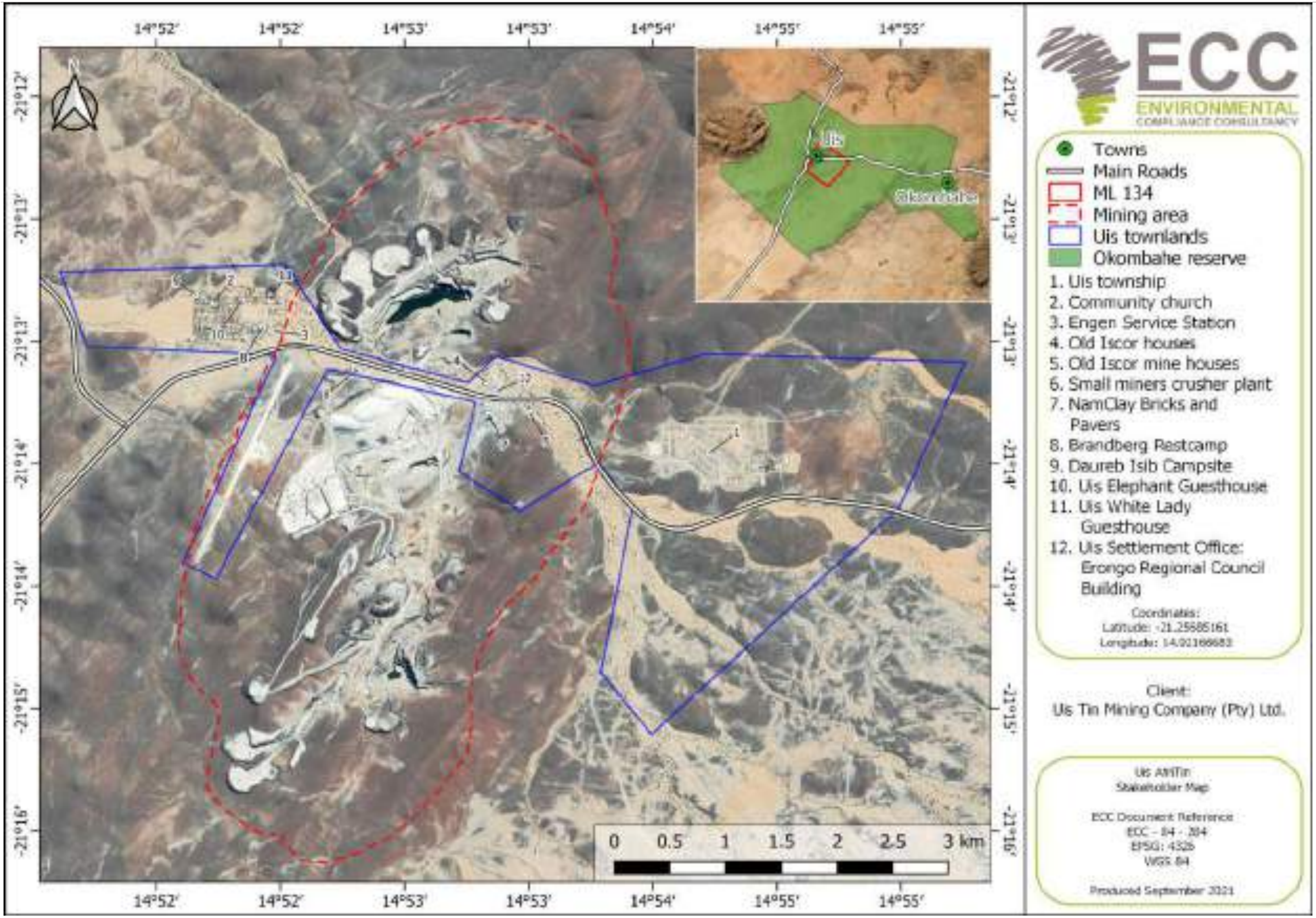

Figure 6 – Stakeholders in and surrounding the mining licence area

2.4.2 SUMMARY OF ISSUES RAISED

During the ESIA process, several stakeholders were engaged for input and feedback on potential issues or concerns regarding the proposed Project. A focus group meeting was held on the 16th of September 2021 at the Uis Settlement Office, but only one attendee showed up for the meeting. A follow-up public meeting was held at the same venue on the 19th of October 2021 with more participants in attendance this time around. Minutes of this meeting and attendance registers can be found in Appendix B. Overall, the proposed Project received significant positive feedback and was well received by the public.

The matters raised could be considered typical concerns for this scale of Project, and these can be summarised as follows:

- Heritage impacts
- Power and water supply
- Waste management
- Waste resource management
- Visual impacts
- Biodiversity impacts
- Socioeconomic and social impacts, such as job creation, training opportunities skills development for youth and unskilled workers, staff housing and accommodation, local housing overall, in migration and informal settlement growth, and the lack of amenities in Uis
- Potential pollution impacts
- Mine closure, and ideas for the site and related assets (pits, mine rock, etc.).

To ensure that interested and affected parties could comment and provide feedback on the initial scoping report, the completed scoping report was circulated to potentially interested and or affected parties, and stakeholders of the Project for a 21-day review period.

The draft ESIA report was circulated to all registered I&APs for an opportunity to review and comment on the findings of the report.

3 REVIEW OF THE LEGAL ENVIRONMENT

This chapter outlines the regulatory framework applicable to the proposed Project. As stated in Section 1, an environmental clearance is required for any activity listed in the Government Notice No. 29 of 2012 of the EMA. The Proponent holds a valid environmental clearance certificate for its current mining (Phase 1) activities.

The Project area is located outside of any national parks, heritage listed areas, or areas of significance. The Project area is not located within a groundwater-controlled area, as regulated under the Water Management Act of 1956.

A thorough review of relevant legislation has been conducted for the proposed Project. Table 3 below identifies relevant legal requirements specific to the Project. Table 4 provides the national policies and plan and Table 5 lists specific permits for the Project.

3.1 National Regulatory Framework

Table 3 – Details of the regulatory framework as it is applied to the proposed Project

ACT	SUMMARY	APPLICABILITY TO THE PROJECT
Constitution of the Republic of Namibia (1990).	The constitution defines the country's position in relation to sustainable development and environmental management. The constitution refers that the state shall actively promote and maintain the welfare of the people by adopting policies aimed at the following: "Maintenance of ecosystems, essential ecological processes and biological diversity of Namibia, and the utilisation of living, natural resources on a sustainable basis for the benefit of all Namibians, both present, and future."	The proposed Project is committed to the sustainable use of the environment, and has aligned its corporate mission, vision, and objectives within the ambit of the Constitution of the Republic of Namibia (1990).
Minerals (Prospecting and Mining) Act No. 33 of 1992.	The Act provides for the granting of various licences related to mining and exploration. Section 50 (i) requires: "An environmental impact assessment indicating the extent of any pollution of the environment before any prospecting operations or mining operations are being carried out, and an estimate of any pollution, if any, likely to be caused by such prospecting operations or mining operations." The Act sets out the requirements associated with licence terms and conditions, such that the holder of a mineral licence shall comply with. The Act also contains relevant provisions for pollution control related to mining activities and land access agreements and provides provisions that mineral licence holders are liable for any damage to land, water, plant, or animal life, caused by spilling or pollution, and must take all such steps as	The proposed mining activity requires an ESIA to be carried out, as it triggers listed activities in the Environmental Management Act's regulations. The Project shall be compliant with Section 76 of the Act with regards to records, maps, plans and financial statements, information, reports, and returns submitted.

ACT	SUMMARY	APPLICABILITY TO THE PROJECT
	may be necessary to remedy such spilling, pollution, loss, or damage, at its own costs.	
Environmental Management Act, 2007 (Act No. 7 of 2007) and its regulations	The Act aims to promote sustainable management of the environment and use of natural resources. The Act requires certain activities to obtain an environmental clearance certificate prior to Project development. The Act states that an EIA should be undertaken and submitted as part of the environmental clearance certificate application process. The MEFT is responsible for the protection and management of Namibia's natural environment. The Department of Environmental Affairs, under the MEFT, is responsible for the administration of the EIA process.	This environmental scoping report documents the findings of the scoping phase of the environmental assessment undertaken for the proposed Project. The process has been undertaken in line with the requirements under the Act and its regulations.
Water Act, 1956 (Act No. 54 of 1956)	Although the Water Resources Management Act (No. 11 of 2013), has been billed, but not promulgated, it cannot be enacted, as the regulations have not been passed – therefore the Water Act of 1956 remains the current piece of legislation relating to water management in Namibia. This Act provides for the control, conservation and use of water for domestic, agricultural, urban, and industrial purposes; and to make provision for the control of certain activities on or in water. The Department of Water Affairs, within the Ministry of Agriculture, Water and Land Reform (MAWLR), is responsible for the administration of the Act.	The Act stipulates obligations to prevent the pollution of water. Measures to minimise potential surface and groundwater pollution are contained in the EMP. The Project is obliged to have all permits relevant to its operations under this Act. Abstraction of water from boreholes requires an abstraction permit to be obtained from the Ministry of Agriculture, Water and Land Reform. The placement of mining infrastructure, such as the tailings storage facility, and the location of industrial effluent storage ponds, require consideration in terms of the Water Act, for example: Condition 4 of

ACT	SUMMARY	APPLICABILITY TO THE PROJECT
		GN 704 – indicates that no person in control of a mine or activity may locate or place any residue deposit, dam, reservoir, together with any structure of other facility within the 1:100-year flood line or within a horizontal distance of 100-metre from any watercourse.
Soil Conservation Act, No. 76 of 1969	This Act makes provision for the prevention and control of soil erosion, and for the protection, improvement, and conservation of soil and vegetation.	The proposed Project is already on an existing and disturbed area, and land may be cleared were necessity. Planned activities will take place within the boundaries of the mining licence and on previously disturbed land. Measures for potential impact due to land clearing will be included in the EMP to ensure conservation of soil and vegetation that will be affected by or used as part of the rehabilitation phase of the Project.
The Forestry Act, No. 12 of 2001 as amended by the Forest Amendment Act, No. 13 of 2005	Section 22 deals with the protection of natural vegetation that is not part of the surveyed erven of a local authority area as defined. Section 23 requires a permit from the Director for the clearance of vegetation on more than 15 ha on any piece of land or several pieces of land situated in the same locality as that which has predominantly woody vegetation; or cut or remove more than 500 cubic metres of forest produce from any piece of land in a period of one year.	The Project activities will require vegetation clearing. The Proponent will ensure that all required permits are in place before vegetation removal commences.
National Heritage Act, No. 27 of 2004.	The Act provides provision for the protection and conservation of places and objects with heritage significance.	Since the proposed Project area is an already operational area, it is unlikely that there is potential for heritage related objects to be found in the

ACT	SUMMARY	APPLICABILITY TO THE PROJECT
	Section 55 compels mining companies to report any archaeological findings to the National Heritage Council. Subsection 9 allows the NHC to issue a consent, subject to any conditions that the Council deems necessary.	mining licence area. However, the relevant stipulations in the Act will be taken into consideration and incorporated into the EMP. In cases where heritage sites are discovered, a generic Chance Find Procedure will be used.
Labour Act, No. 11 of 2007	The Labour Act, No. 11 of 2007 (Regulations relating to the Occupational Health & Safety provisions of Employees at Work, promulgated in terms of Section 101 of the Labour Act, No. 6 of 1992 - GN156, GG 1617 of 1 August 1997)	The Project shall adhere to all labour provisions and guidelines, as enshrined in the Labour Act as a minimum requirement. The Proponent shall ensure industry best practices and international standards used within the mining and processing industry utilising acids shall be applied on site. The Project shall also develop and implement a comprehensive occupational health and safety plan to ensure adequate protection for its personnel throughout the Project lifecycle.
Road Traffic and Transport Act, No. 22 of 1999	This Act makes provision for the control of traffic on public roads, the licensing of drivers, the registration and licensing of vehicles, and the control and regulation of road transport users across Namibia.	The Project will involve normal and specialised transportation activities in support of mining activities. The employees and support business shall adhere to national road regulations on public roads.
Hazardous Substances	This Ordinance provides for the control of toxic substances and can be applied in conjunction with the Atmospheric Pollution Prevention Ordinance, No. 11 of 1976.	The planned Project will involve the handling and storage of hazardous substances such as fuels, reagents, and industrial chemicals. The Proponent

ACT	SUMMARY	APPLICABILITY TO THE PROJECT
Ordinance, No. 14 of 1974	This applies to the manufacture, sale, use, disposal, and dumping of hazardous substances, as well as their import and export.	shall ensure safe handling, transfer, storage, and disposal protocols are developed, implemented, and audited throughout its operations. The Proponent is obliged to ensure that all permits under this Ordinance are obtained prior to Project commencement.
The Atmospheric Pollution Prevention Ordinance, No. 11 of 1976	The Ordinance pertains to the prevention of air pollution, with particular focus on public health, and contains detailed provisions on air pollution matters, including the control of noxious or offensive gases, atmospheric pollution by smoke, dust control, motor vehicle emissions, and other general provisions. Specific attention should be paid to Section 5 (1) (b)" erect or cause to be erected any building or plant, which is intended to be used for the purpose of carrying on any scheduled process in or on any premises, unless he is the holder of a provisional registration certificate authorising the erection of that building or plant for the said purpose…"	The nature of mining activities does generate dust. Activities within the mining operations and processing plant will generate gases, odours, and air pollution. The Proponent will ensure that all measures reasonably practicable will be implemented to reduce and mitigate impacts to air quality, and this will be included in the EMP. Hydrofluoric acid and sulphuric acid are likely to be used in the DMS and flotation circuit (wet system) once this circuit is commissioned in the future. According to Schedule 2 Section 21. Hydrofluoric Acid Works within the Ordinance identifies: b) "processes in which hydrofluoric acid is used" should be permitted. Therefore, the Proponent should apply for the provisional registration certificate issued under

ACT	SUMMARY	APPLICABILITY TO THE PROJECT
		section 6(2)(b)(i) or (3) of this Ordinance utilising the prescribed form.
The Atomic Energy and Radiation Protection Act of 2005	Section 16 (1) Except when such activity is explicitly authorised by a licence, no person may (a) possess any radiation source or nuclear material unless that person has in every case made a notification as contemplated in section 17(1) and an authorisation has been issued in terms of section 17(3). (2) No person may without a licence (b) operate or use any radiation source or instruct, or permit any person in his or her employ or acting in any manner on his or her behalf or promoting his or her interests to operate or use any radiation source. In addition, (4) No person may use or operate any radiation source, unless that source as well as the facilities in which such a source is being operated, is registered as provided by this Act. The periods of storage and transportation may be prescribed for different classes of radiation applied for on the licence.	The Proponent intends to install a sensor-based sorting system within the dry section of the bulk sampling and sorting facility that will use an X-ray transmission (XRT) sorter powered by X-ray technology and a densitometer (density gauge) in the DMS plant within the bulk sample, sorting and testing facility. The Proponent will need to apply for the relevant licence authorising them to be in possession of a radiation source and the operation thereof within the plants.

3.2 National polices and plans

Table 4 – Namibian national polices and plans applicable to the proposed Project

POLICY OR PLAN	DESCRIPTION	RELEVANCE TO THE PROJECT
Vision 2030	Vision 2030 sets out the nation's development targets and strategies to achieve its national objectives. Vision 2030 states that the overall goal is to improve the quality of life of the Namibian people aligned with the developed world.	The proposed Project shall aim to meet the objectives of Vision 2030 and shall contribute to the overall development of the country through continued employment opportunities and ongoing contributions to the gross domestic product (GDP).
Fifth National Development Plan (NDP5)	The NDP5 is the fifth in a series of seven five-year national development plans that outline the objectives and aspiration of Namibia's long-term vision. The NDP5 pillars are economic progression, social transformation, environmental sustainability, and good governance.	The planned Project supports meeting the objectives of the NDP5 through creating opportunities for continued employment.
The Harambee Prosperity Plan ii (2021 – 2025)	Second Pillar: Economic advancement – ensuring increasing productivity of priority key sectors (including mining) and the development of additional engines of growth, such as new employment opportunities.	The Project will contribute to the continued advancement of the mining industry and create an additional employment generation engine within the regional and national landscape.
Minerals Policy	The Minerals Policy was adopted in 2002 and sets guiding principles and direction for the development of the Namibian mining sector, while communicating the values of the Namibian people.	The planned Project conforms to the Policy, which has been considered through the ESIA process and the production of this report. The Proponent intends to continue to support local spending and procurement.

POLICY OR PLAN	DESCRIPTION	RELEVANCE TO THE PROJECT
	The policy strives to create an enabling environment for local and foreign investments in the mining sector and seeks to maximise the benefits for the Namibian people from the mining sector, while encouraging local participation. The objectives of the Minerals Policy are in line with the objectives of the Fifth National Development Plan that include reduction of poverty, employment creation, and economic empowerment in Namibia.	The Project will comply with the general guidelines of the Policy through the adoption of various legal mechanisms to manage all aspects of the environment effectively and sustainably from the start. The ESIA is one such mechanism to ensure environmental integrity throughout the planned Project's lifecycle.

3.3 PROJECT PERMITS

Table 5 – Specific permits and licence requirements for the proposed Project

Permit or licence	Act / Regulation	Related activities requiring permits	Relevant authority
Environmental clearance certificate	Environmental Management Act, No. 7 of 2007	Required for all listed activities shown in Table 2.	Ministry of Environment, Forestry and Tourism (MEFT)
Mining licence	Section 90 (2) (A) of the Minerals Act, No. 33 of 1992	Written permission from the mining commissioner.	Ministry of Mines and Energy (MME)
Surface rights agreements (mine, infrastructure corridors)	Section 52(1)(A) of the Minerals Act, No. 33 of 1992	Included in the mining licence application. Also required in the permit application for accessory works areas.	Ministry of Mines and Energy (MME)
Exclusive prospecting licences	Section 68 (2) (A) of the Minerals Act, No. 33 of 1992	Written permission from the mining commissioner before prospecting can commence.	Ministry of Mines and Energy (MME)

Permit or licence	Act / Regulation	Related activities requiring permits	Relevant authority
Accessory work permit	Section 90(3) of the Minerals Act, No. 33 of 1992	Written permission from the mining commissioner before accessory works can be erected on an EMP or mining licence area.	Ministry of Mines and Energy (MME)
Permit for boreholes (exploration and water boreholes)	A permit is issued under the Water Act, No. 54 Of 1956 (enforced)	Required before the drilling of boreholes for exploration and the abstraction of water.	Ministry of Agriculture, Water and Land Reform (MAWLR)
Tailings waste disposal permit	A permit is issued under the Water Act, No. 54 of 1956 (enforced)	Required for the disposal of tailings.	Ministry of Agriculture, Water and Land Reform (MAWLR)
Wastewater discharge permit	A permit is issued under the Water Act, No. 54 Of 1956 (enforced) but form types that fall under the Water Act, No. 24 of 2004 are used.	Required for discharge of sewage and/or excess industrial or mine wastewater.	Ministry of Agriculture, Water and Land Reform (MAWLR)
Permit for the clearing of land	The Forest Act, 2001 (Act No. 12 of 2001)	This Act governs the removal of vegetation within 100 m of a water course, or removal of more than 15ha of woody vegetation, or the removal of any protected plant species.	Ministry of Agriculture, Water and Land Reform (MAWLR)
Permit for the destruction of heritage objects and artefacts	The Heritage Act, No. 27 of 2004.	This Act relates to interference with heritage artefacts during the Project life. Heritage sites could potentially be located within the proposed mining licence footprint.	National Heritage Council (NHC)
Consumer installation certificate for bulk fuel storage	Petroleum Products Regulations	A consumer installation certificate is required for bulk fuel storage and dispensing.	Ministry of Mines and Energy (MME)

Permit or licence	Act / Regulation	Related activities requiring permits	Relevant authority
Licence for explosives magazine	Minerals (Prospecting and Mining) Act, No. 33 of 1992; Mine Safety Regulations	This is also covered under the accessory works application.	Ministry of Mines and Energy (MME)
Permit for the storage and use of explosives, and the burning of packaging	Minerals (Prospecting and Mining) Act, No. 33 of 1992; Mine Safety Regulations	Part x (10), explosives and blasting.	Ministry of Mines and Energy (MME)
Provisional registration certificate to erect a building or plant that utilises hydrofluoric acid. HF is a regulated substance under nuclear non-proliferation treaties as it is used in the enrichment of uranium. End users need to apply for an End User Certificate. This certificate will in turn be used to apply for the export licence.	Atmospheric Pollution Prevention Ordinance 11 of 1976	Section 6 (2) (b) (i) or 7 (3) of the Ordinance	Ministry of Health and Social Services (MoHSS)
Application for a licence to use a radiation source as per Section 16 (1)(2) and Section 21 (a) to (i)	Atomic Energy and Radiation Protection Act 5 of 2005	Section 16 (1)(2)	Ministry of Health and Social Services (MoHSS)

3.4 WORLD BANK STANDARDS

The International Finance Corporation (IFC) is a member of the World Bank Group and is the largest global development institution focusing on the private sector in developing countries. Its standards have become a global benchmark for environmental and social performance. They form the basis for the Equator Principles (IFC, 2013), a voluntary environmental and social risk-management framework used by 77 financial institutions worldwide.

The Equator Principles are a framework and set of guidelines for evaluating social and environmental risks in project finance and apply to all new projects with a total capital cost of US$10 million or more, no matter what industry sectors are considered. Depending on the funding mechanism for the project, the Equator Principles may be applicable to this project. If so, the IFC performance standards that may be applicable are provided in Table 6 below.

Table 6 – Applicable IFC Performance Standards

IFC Standards	Relevance
Performance standard 1	Assessment and management of environmental and social risks and impacts
Performance standard 2	Labour and working conditions performance standard
Performance standard 3	Resource efficiency and pollution prevention performance
Performance standard 4	Community health, safety, and security
Performance standard 5	Land acquisition and involuntary resettlement
Performance standard 6	Biodiversity conservation and sustainable management of living natural resources
Performance standard 8	Cultural heritage

4 PROJECT DESCRIPTION

4.1 BACKGROUND

In 2018 the Uis Tin Mine infrastructure development commenced on the historical Uis Tin Mine located adjacent to the Uis mining village which was built and developed to support the historical mine.

A Definitive Feasibility Study (DFS) hereinafter referred to as DFS was conducted between October 2020 and December 2020 for the expansion of production at Uis Tin Mining Company with the intention to fast-track opportunities to implement Stage II of Phase 1 by leveraging the mine's existing capabilities to increase tin production and finding feasible opportunities to add by-products to the operation. During 2021 and 2022, the mine embarked on additional metallurgical test work investigating the feasibility of extracting and processing lithium concentrate on a pilot scale. Results were positive at a 10% production rate with a purity level of 94% $Li2O5$.

The expansion of the materials handling and concentrating plant (Plant) was designed to increase the average overall monthly production from 80 to 120 tonnes of tin concentrate which form the basis for the Stage II expansion methodology. To achieve increased production, selected mechanical systems upgrades within the existing Plant will be applied, a tantalum processing circuit will be added onto the existing Plant and a new bulk sample, sorting, and testing facility will be constructed adjacent to the existing Plant. One such an example of a mechanical upgrade entails increasing the ore feed rate by 50% in the existing circuits. Other mechanical improvements to the operation of the tin and tantalum concentrating circuits will be applied to continue to achieve a consistent recovery of ore (DFS, 2021). This will be achieved by:

- Increasing the throughput capacity by 50% to 120 tph, which can be achieved by modular expansion of individual circuits;
- Improving the overall recovery of tin from 60% to 70% (currently at 64%) by adding beneficiation capacity for tailings streams in the concentrator, which are currently discarded;
- Introducing a tantalum (Ta) by-product stream and targeting a recovery of 10% at the initial production stage;
- Improving the overall recovery of tantalum from 15% to 30% by optimising liberation between the tin- and tantalum-bearing minerals, which includes improved magnetic separation efficiency, and

- Introducing another by-product in the form of petalite concentrate (lithium concentrate) which is used in the ceramic industry with the potential to be used in the production of lithium batteries.

The Project requires a capital investment of approximately N$100 million and will be financed by a financial investment institution.

4.2 THE TRANSITION FROM HISTORICAL TO CURRENT MINING

The historical tin mine, under ownership by ISCOR, extracted ore from 14 different pegmatite ore bodies spread over an area of approximately 2 km east-west and 4 km north-south (Figure 7). The historical mine did not conduct rehabilitation work on its open pits and waste rock dumps leaving access to previously developed mining faces. These open pit faces are currently being mined further under ML 134 issued to UTMC, therefore eliminating the need for major pre-stripping or costly mining development work (DFS, 2021).

Since Uis Tin Mining Company (Pty) Ltd took ownership of the mine in 2018, construction of the Pilot Phase 1 Stage I tin ore processing and concentrating infrastructure and establishing supporting infrastructure for the mining and processing operations was developed and completed in 2019.

This strategy allowed UTMC to initially focus on the production of tin concentrate (cassiterite mineral) which also contains tantalum (columbite-tantalite) and lithium (as petalite). By the end of December 2020, more than 312 tonnes of tin concentrate at a grade exceeding 60% Sn had been produced and exported to the Thailand Smelting and Refining Company Ltd ("Thaisarco") under a fixed off-take agreement (DFS, 2021). The off-take agreement payable price is directly linked to the LME tin price at the date of sale (DFS, 2021). The ramp-up construction work is anticipated to take approximately six months to complete with initial by-product production envisioned to commence in late 2022.

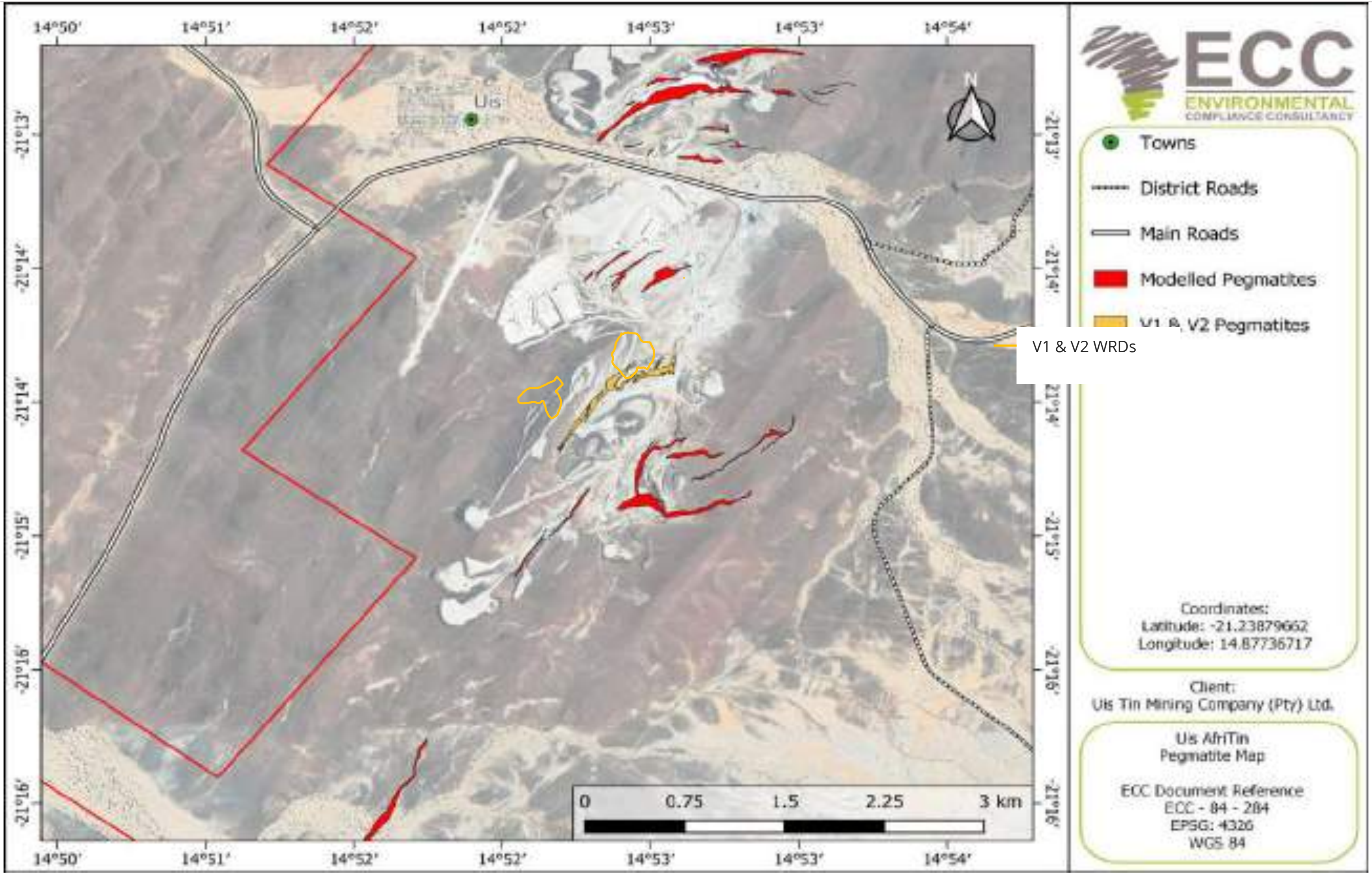

Figure 7 - Historical open pits and pegmatite-tin ore.

4.3 NEED FOR THE PROJECT

Mining activities contribute to the national and local economies of Namibia. UTMC expects the development and operation of the proposed Phase 1 Stage II mining and additional processing activities to have a positive impact on the Namibian economy. Mining is a significant economic driver and source of investment in Namibia (Uusiku, 2021). The Namibian economy can expect sustained benefits from revenues created during the operational phase of the Stage II expansion program, in the form of royalties and taxes during the life of mine (LoM). Additionally, the operation of the mine will create a positive contribution towards employment both locally and regionally.

UTMC has achieved steady-state production with the Phase 1 pilot plant and recorded a month-on-month increase in Plant throughput. Currently, the Plant production is consistently achieving and surpassing design capacity. UTMC plans to enhance its profitability by increasing the plant's production capacity further in three successive stages. The scope of the ESIA is limited to existing operations and proposed Stage II operations.

UTMC intends to add a bulk sample, sorting and testing facility adjacent to the existing processing plant. The purpose of the bulk sample processing facility is to undertake metallurgical test work on the material (ore) from the existing mine pits, as well as from external areas where exploration work is being undertaken to assess the process required to extract minerals from the ore(s). Extraction of minerals such as tin, tungsten, tantalum, lithium, copper, silver, and gold will be assessed in this facility. The focus of the mine, however, will be on the extraction of tin, tantalum, and lithium for resale purposes.

The lithium resource is contained within the current orebody, therefore making it operationally viable for lithium concentrate (4% $Li2O5$) to be produced as a saleable by-product of the existing operation. Positive metallurgical test results allow the mine to progress to the design and construction of a lithium pilot plant at Uis (Andrada, 2022) of which the scale and potential impacts stemming from this will be assessed in the ESIA report.

Petalite lithium concentrate produced from the pilot plant within the bulk sampling, sorting, and testing facility is intended for initial sales into the premium glass and ceramic markets, and test material for existing and or prospective converters of lithium ore concentrates to battery-grade lithium (Viljoen, 2022).

The facility is a testing facility, which will not run continuously. Testing campaigns will run for a maximum of 100 hours (approximately 4 days) after which the plant will be stopped for cleaning to prevent contamination between sampling campaigns. It is expected that one, with a maximum of two, testing campaigns will run per month. The facility will comprise a run of mine (ROM) pad, the metallurgical support facility (MSF), the bulk splitting area, and the dense media separation (DMS) and flotation processing facilities. Associated infrastructure will include offices, water storage tanks and treatment facilities, chemical offloading and storage areas, haul roads, and light vehicle roads.

The location of the bulk sample, sorting, and testing facility is shown in Figure 8, Figure 9 and Figure 10.

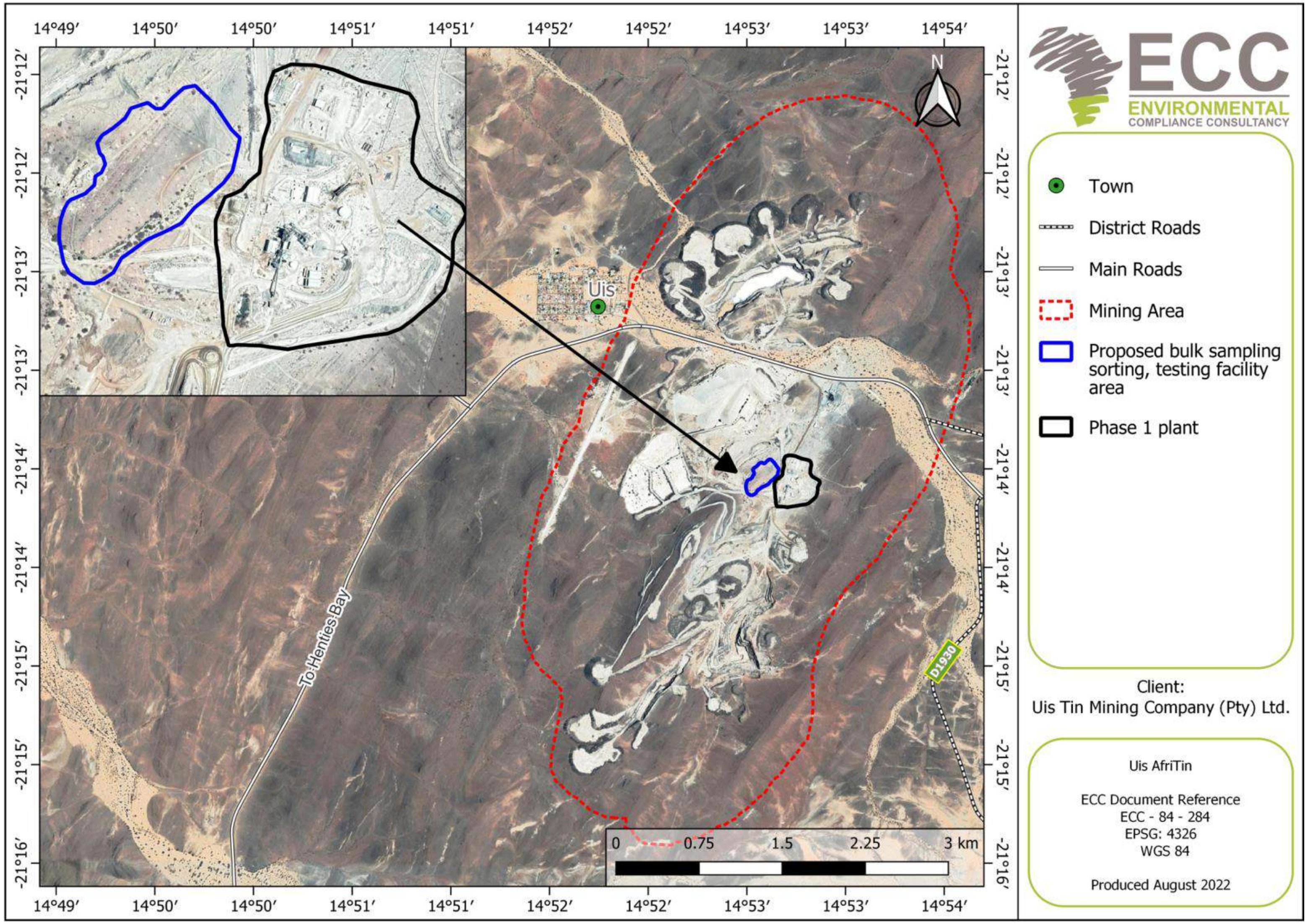

Figure 8 - Position of the bulk sampling, sorting, and testing facility in relation to the existing Sn pilot plant

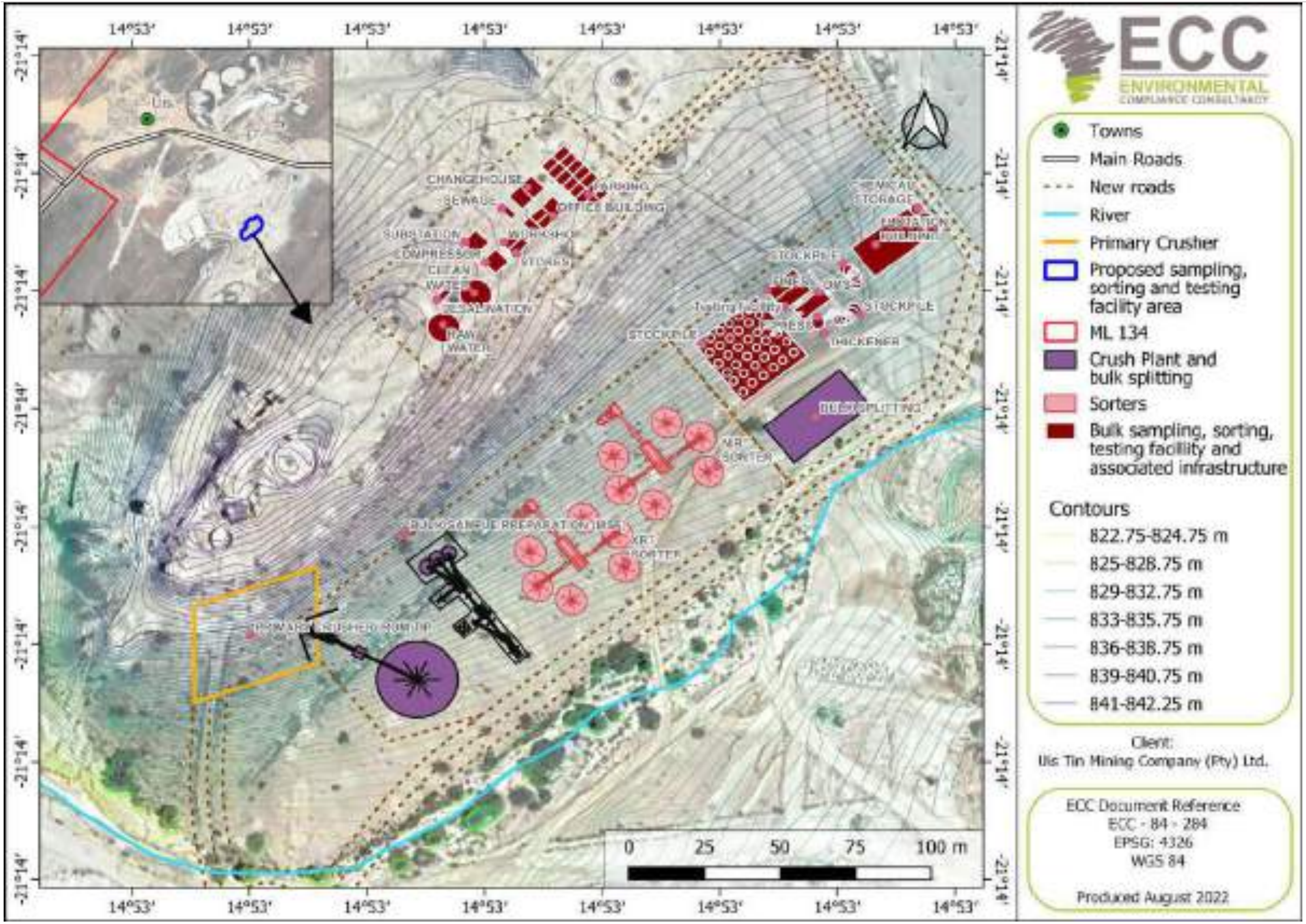

Figure 9 - Location of the bulk sampling, sorting, and testing facility infrastructure and administration block

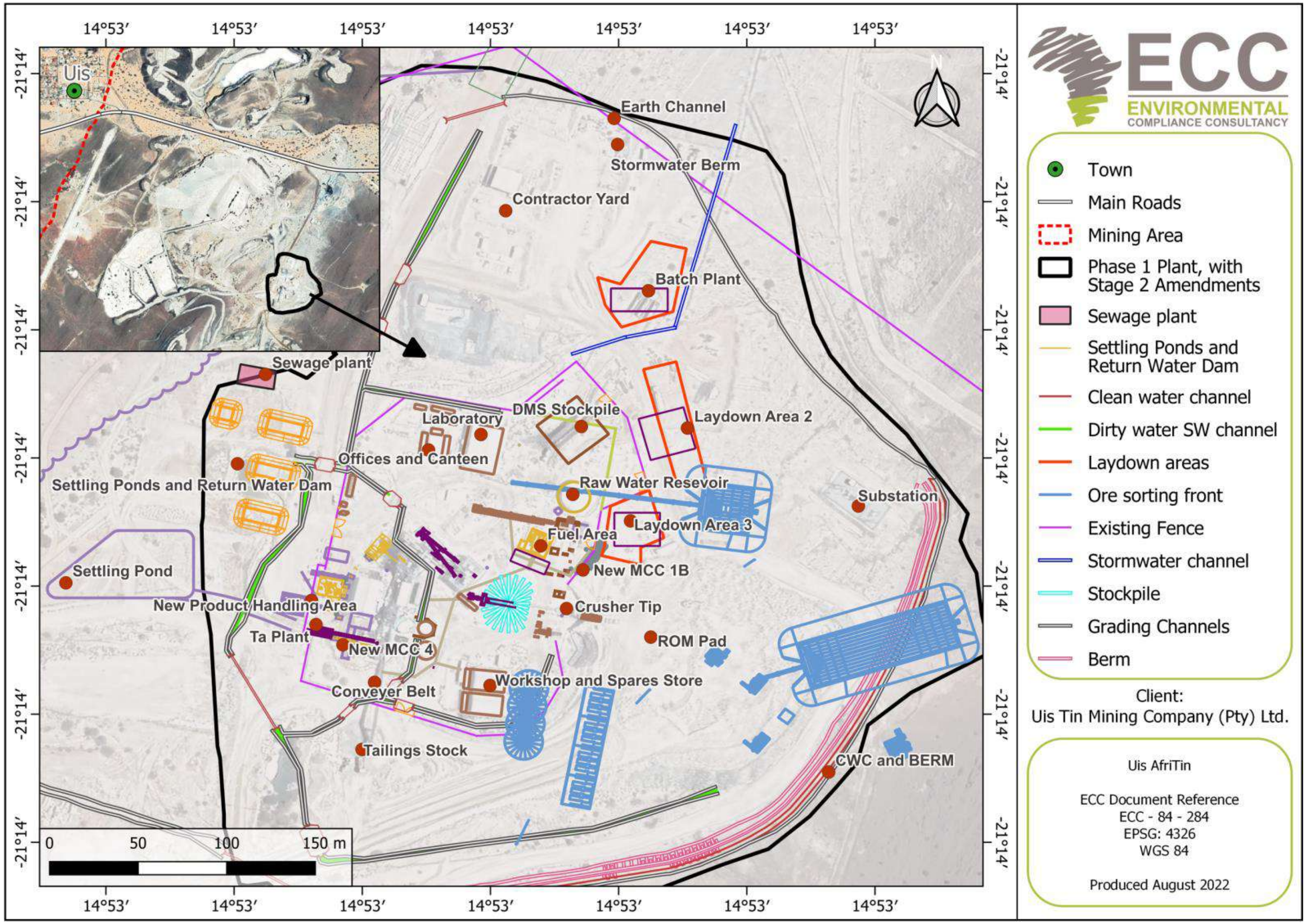

Figure 10 - Existing pilot plant that will undergo modifications for Stage II components

4.4 ACCESS AND ROAD CONDITIONS

The existing site access is accessed via a T-junction turn-off along the C36 roadway, Figure 11. The control at the mine access is free flow along the C36 and stop/priority controlled on the development exit (ITS, 2022).

From the towns of Henties Bay and Omaruru, access can be gained to other larger towns and cities via tarred roads. The closest larger towns to the Project are Omaruru and Henties Bay located 122 km west and 124 km east, respectively by road from the Project. Walvis Bay is a port city 40 km from Swakopmund by road, with an international airport, and import and export infrastructure. Uis is located approximately 270km northwest of the Namibian capital, Windhoek (DFS, 2021).

There is a boom-control point along this access road at the mine entrance, which is located approximately 500 meters south of the C36 roadway. The mine used to have a secondary access along the C36, however this access is no longer in use by the mine. This secondary access was located approximately 420 meters west from the existing mine access. The current speed limit along the C36 roadway is 100km/h. The required Shoulder Sight Distance (SSD) for this operational speed, is 200 meters for cars and 300 meters for a single unit truck (Urban Transport Guidelines UTG 1).

The available SSD on either side of the road at this exit is approximately 240 meters, which is sufficient for cars, but it is insufficient for trucks. To improve the safety at this exit, it is recommended to reduce the speed limit along the C36 at the mine exit to 80 km/hr, for at least 1 km on either side of the mine access intersection. The required SSD for an 80 km/h design speed environment is 240 meters for trucks. With this reduced speed limit along the C36 to 80 km/h, sufficient SSD would be available for trucks (ITS, 2022).

The condition of the C36 road, near the development, is in relatively poor condition with various spots of cracking and pavement failure. There are various reasons for this type of failure, but it is most likely due to excessive truck loads and excessive travel speeds.

Imports of industrial goods and equipment from South Africa are done via Windhoek via the B1 and B6 main roads, while most imports from overseas come by sea through Walvis Bay. Concentrate export from UTMC is by road and sea via Walvis Bay.

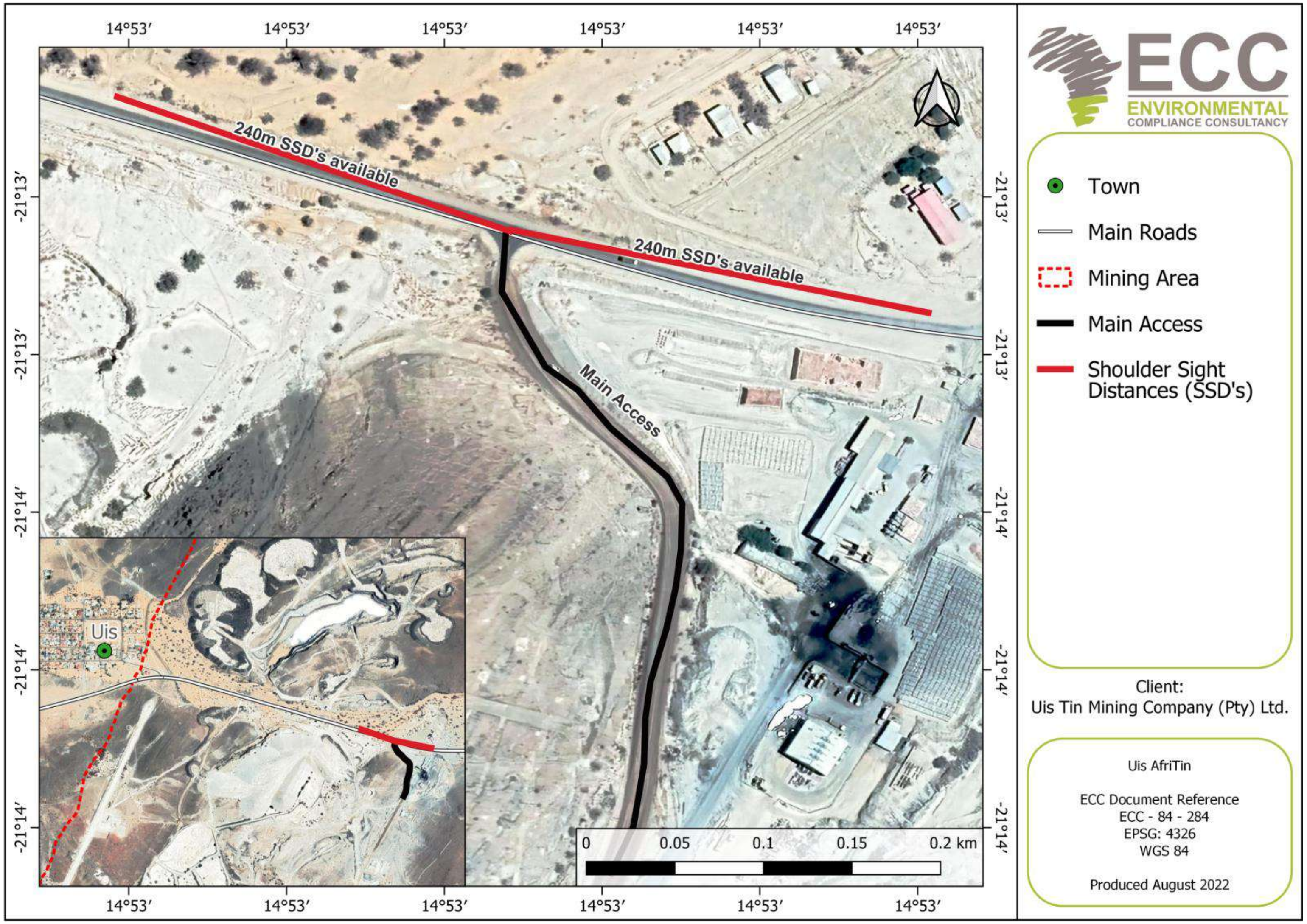

Figure 11 - Directional shoulder sight distance available at the main entrance off the C36

4.5 Mining and pit design parameters

Typical opencast mining is used to excavate cassiterite-bearing pegmatite ore. The pegmatite is present as large, sub-vertical and outcropping veins up to 100 m in thickness. Phase 1 Stage I and Stage II mining activities will take advantage of the exposed outcrops and accessible mine workings (historical) through conventional open pit mining methods. At a current stripping ratio of 1:1.5 due to the necessity of increased waste removal as pegmatite is mined at depth. The current plan provides a LoM of 18 years with 20 years of processing (DFS, 2021).

An overall pit slope angle design of 55 degrees (crest to crest) was selected using digital measurements on the generated digital terrain model (DTM) therefore limiting mining bench heights to 10 m for stability and operational reasons. The approach forms part of a five-year mine plan that prioritises the reduction of overburden stripping in the initial stages, extracting higher volumes of pegmatite and conversion of ore into saleable tin concentrate for export (DFS, 2021). See Figure 12 illustrating the current ore mining and processing infrastructure placement from an aerial perspective.

Figure 12 - UTMC Mine and Ore Processing Infrastructure (Source: Minxcon, 2020)

The proposed mining method is illustrated below (Figure 13). All mining is completed by contractors. The mining production schedule has been tested and is set to achieve a fixed target per production quarter.

Figure 13 - Proposed Mining Method (Source: Minxcon, 2021)

4.6 MINING FLEET

Mining operations are contracted to Nexus-Ino Mining who is responsible for pit work and haulage. See Table 7 of the current fleet of mining equipment and to be used for the Stage II expansion operations. More mining equipment will be brought in once production is stabilised in line with the design capacities of future stages. Drilling and blasting will be performed on 10 m benches and loading will take place in 2.5 m flitches in the mineralised zones to enhance dilution control.

Table 7 - Current Mining Fleet (Source: Nexus-Ino Mining, 2021)

No.	Plant Number	Make	Description
1	TT126	Scania GX460	40t Tipper Truck
2	TT127	Scania GX460	40t Tipper Truck
3	AD008	Bell B30	30t Tipper Truck
4	AD009	Bell B30	30t Tipper Truck
5	AD010	Bell B30	30t Tipper Truck
6	TT084	Powerstar 2628	10m3 Tipper Truck
7	TT097	Powerstar 2628	10m3 Tipper Truck
8	EX009	New Holland E305B	30t Excavator
9	EX015	Kobelco SK500	50t Excavator
10	EX017	Kobelco SK380	38t Excavator
11	LD020	Cat 95066	Front End Loader

No.	Plant Number	Make	Description
12	LD022	Cat 950	Front End Loader
13	LD024	Cat 226B3	Skid Steer
14	TLB05	JCB 3Dx 4WD	Tractor Backhoe Loader
15	TLB08	Cat 426F2	Tractor Backhoe Loader
16	BD010	Cat D7	Track Bulldozer
17	WT121	Dezzi	23000l Water truck
18	GR022	LuiGong CLG425	Wheel Grader
19	Workshop	Fima 40055	500l Compressor
20	Workshop	Rato	420cc Welder

4.7 GEOLOGY AND MINERALISATION

The tin-bearing pegmatite intrusions occurring at the Uis Tin Mine are part of the Pan-African Damara Belt, which is the northeast-trending branch of the Damara Orogen in Namibia. The Damara Supergroup comprises metasedimentary and metavolcanic lithologies of the Damara Belt and is divided into various tectonostratigraphic zones. Economically mineralised pegmatites are post-tectonic and represent highly evolved magmatic systems. The pegmatites of the Damara Belt are grouped into various northeast-trending pegmatite belts and occur in a variety of morphologies (DFS, 2021).

The Uis Tin Mine occurs at the north-eastern extent of the 120 km long Cape Cross–Uis Pegmatite Belt (CUPB), or the northern tin belt, extending from Cape Cross to the town of Uis and is known for its abundant tin mineralisation. The CUPB is separated from the Northern Central Zone which hosts the Nainais-Kahero pegmatite belt, or central tin belt, by the Autseib Fault. ML 134 and ML 129, known as Uis and Tsaurob respectively, occur in the CUPB, while ML 133, known as Nai-nais, occurs in the Nainais-Kahero pegmatite belt. The CUPB hosts a variety of mineralised to barren, syn- to post-tectonic pegmatites (DFS, 2021).

The mining licence ML 134 is approximately 200 km2 in size and includes a large portion of the Sn-Nb-Ta type granitic pegmatites in the Uis swarm. The pegmatites strike to the northeast and east, dipping between 30°NW and 70°NW, and are discordant to the country rocks which generally dip to the southeast. The larger pegmatite bodies appear to pinch out along strike or splay out into different pegmatite veins (DFS, 2021).

The V1/V2 pegmatite is the only orebody for which a Mineral Resource estimate compliant with the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (2012 Edition) ("JORC Code") has been completed. Sixteen historically drilled dykes were mined from eight principal open pits until mine closure in 1990. The pits were named:

K3/K5 pit, the K6 pit, the K8/K10 pit, the P4/P5 pit, the P6 pit, the V1/V2 pit, the V4/V5/V12 pit, and the V9/V10/V13 pit. The surrounding unmined pegmatite intrusions were also considered in this economic assessment where pegmatite size and observed mineralisation matched predetermined specifications. For the JORC study, only surficial data such as geological mapping and structural measurements were available for this latter group of pegmatites (DFS, 2021).

The Uis pegmatites are granitic in composition, containing abundant quartz, orthoclase, muscovite and albite. Minor mineralogy includes tourmaline, garnet, apatite, microcline and beryl. Li-bearing phases include petalite, spodumene (Karlowa Swarm), lepidolite, hectorite, eucryptite and amblygonite. Sn is present in the form of cassiterite, whereas Ta-Nb-oxides occur as columbite (-tantalite) group minerals, tapiolite with minor wodginite, and ixolite (DFS, 2021).

The central cluster of the Uis swarm encompasses approximately 180 standalone pegmatite bodies at various scales and sizes. Figure 7 illustrates a plan view of the previously mined V1 and V2 pegmatites (DFS, 2021).

4.8 Blasting

Blasting (also known as rock fragmentation) is undertaken by drilling and blasting, with the weathered zones requiring blasting with lower powder factors. Blasting is a core component of the mining operation, impacting all downstream mining and comminution (crushing) processes. Blasting also affects dilution factors and the plant's operation and ore recovery.

UTMC concluded a contract for blast-hole drilling operations. Blasting is sourced through a down-the-hole service rendered by Bulk Mining Explosives ("BME") based on separate orders for each blast and conducted on a bi-weekly basis. Blast notices are created and put up at key locations around the Uis settlement as well as at the entrance to the mine site notifying the community of the time and duration of each blast event. A blast and vibration specialist study was commissioned to study the potential effects on sensitive receptors and infrastructure. This work was contracted to Blast Management & Consulting.

Owing to the slow ramp-up of the plant, current mining progressed well ahead of processing, which resulted in a large build-up of inventory on the RoM stockpile, negating any future risks of mining interruptions (DFS, 2021). The blasting cycle may increase to a weekly event during Phase 2.

Ground vibration predictions were done considering distances ranging from 50 m to 3500 m around the opencast mining area. The objective of the blast and vibration specialist study was to outline the expected environmental effects that blasting operations could have on the surrounding environment and to propose the specific mitigation measures that are required to manage the related influences of expected ground vibration, air blast and fly rock. The effects of the blast attributes are investigated in relation to the blast area and surrounds and the possible influence on nearby private installations and houses (Zeeman, 2022).

4.8.1 BLAST VIBRATION METHODOLOGY

The following methodology was applied in the blast vibration assessment.

- Identifying surface structures/installations that are found within a reasonable distance from the project site. A list of Points of Interest (POIs) was created that was used for the evaluation. Google Earth imagery was used.
- Site evaluation: This consists of the evaluation of the mining operations and the possible influences from blasting operations. The methodology is to model the expected impact based on the expected drilling and blasting information provided for the project. Various accepted mathematical equations are applied to determine the attenuation of ground vibration, air blast and fly rock. These values are then calculated over the distance investigated from the site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors then gives an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels then gives an indication of the possible mitigation measures to be applied. The possible environmental or social impacts are then addressed in the detailed ESIA investigation.
- The simulation work done by the specialist (Blast & Management Consultants) provided information that was applied for predicting ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 89 mm diameter single blast hole and the maximum charge was determined from a shock tube timing. The maximum charge relates to the total number of blast holes that detonates simultaneously based on the blast layout and initiation timing of the blast, thus, the maximum mass of explosives detonating at once. The minimum charge relates to 69 kg and the maximum charge relates to 207 kg. These values were applied in all predictions for ground vibration and air blast (Zeeman, 2022).

The evaluation mainly considered a distance up to 3500 m from the pit area. The closest structures observed are the power lines, boreholes, fibre optical cable and mine buildings/structures. The planned maximum charge evaluated showed that it could be problematic for these structures in terms of potential structural damage. The ground vibration levels predicted for these POI's ranged between 0.1 mm/s and 469.3 mm/s for structures surrounding the open pit area (Zeeman, 2022).

Figure 14 - depicts the result of a sensitivity mapping exercise with the identified points of interest (POI) in the surrounding areas for the proposed project area. Three zones of influence were identified by the specialist.

- A highly sensitive area of 500 m around the mining area. Normally, this 500 m area is considered an area that should be cleared of all people and animals prior to blasting. Levels of ground vibration and air blast are also expected to be higher closer to the pit area.
- An area 500 m to 1500 m around the pit area can be considered as being a medium sensitive area. In this area, the possibility of impact is still expected, but it is lower. The expected level of influence may be low, but there may still be reason for concern, as levels could be low enough not to cause structural damage but still upset people.
- An area greater than 1500 m is considered a low sensitivity area. In this area, it is relatively certain that influences will be low with low possibility of damages and limited possibility to upset people.

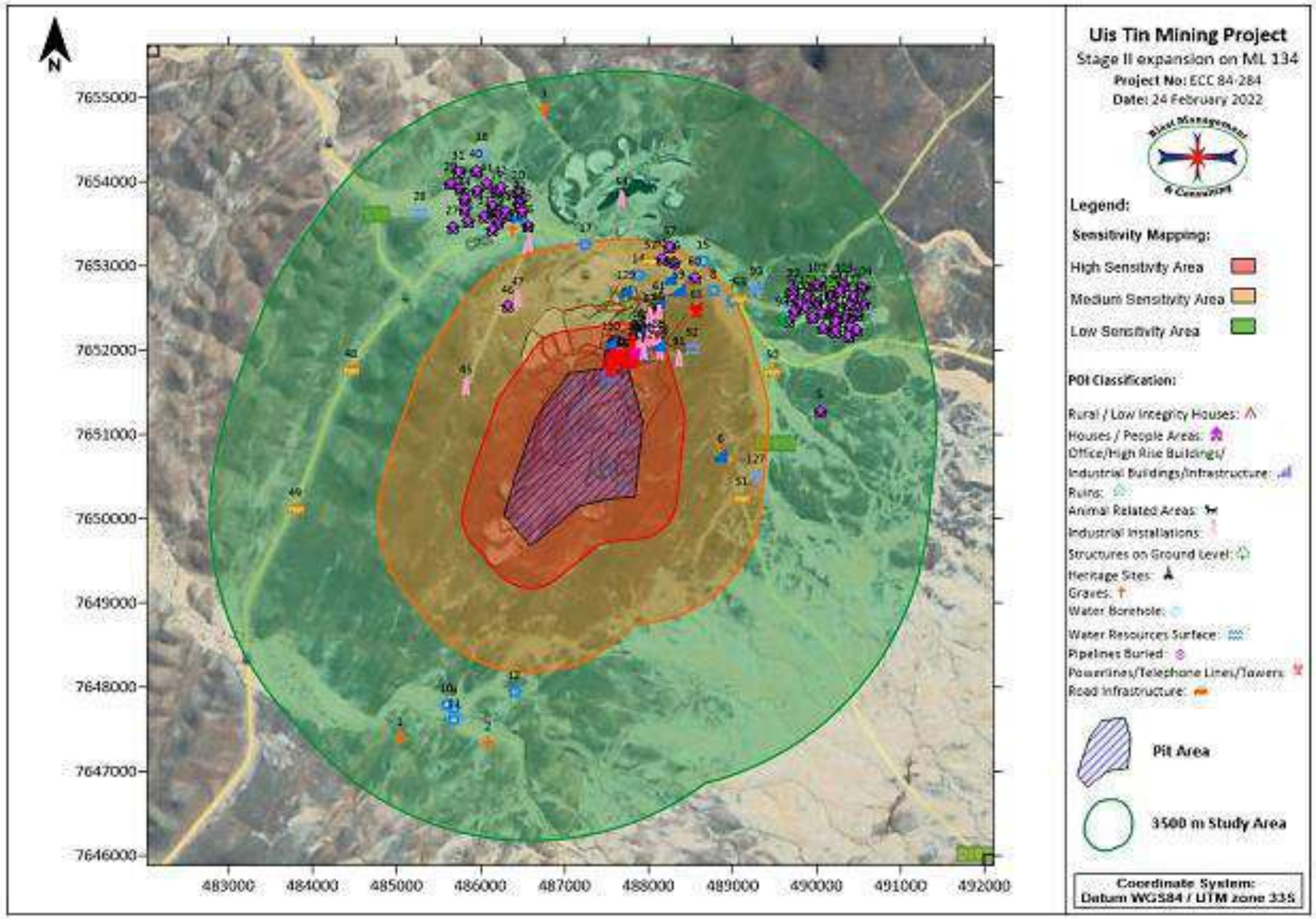

Figure 14 - Identified sensitive areas with identified point of interest (Zeeman, 2022)

4.8.2 GROUND VIBRATION LIMITATIONS ON STRUCTURES

Limitations on ground vibration take the form of maximum allowable levels of intensity for different installations or structures. Ground vibration limits are also dependent on the frequency of the ground vibration. Frequency is the rate at which the vibration oscillates. Faster oscillation is synonymous with higher frequency and lower oscillation is synonymous with lower frequency. Lower frequencies are less acceptable than higher frequencies because structures have a low natural frequency. Significant ground vibration at low frequencies could cause increased structure vibrations due to the natural low frequency of the structure and this may lead to crack formation or damages (Zeeman, 2022).

According to Zeeman (2022) predicting ground vibration and possible decay (Section 4.8.3), a standard accepted mathematical process of scaled distance is used. The equations utilised by the specialist are described in the blast and vibration study (Appendix D).

Based on the designs received from BME on expected drilling and charging, the following Table 8 shows expected ground vibration levels (PPV) for various distances calculated for the two different charge masses. The charge masses are 69 kg and 207 kg for the Pit area. Ground vibration predictions were done considering distances ranging from 50 m to 3500 m around the opencast mining area. The levels used are considered the basic limits that will be applicable for the type of structures observed surrounding the pit area. These levels are: 6 mm/s, 12.5 mm/s, 25 mm/s and 50 mm/s. This enables immediate review of possible concerns that may be applicable to any of the privately-owned structures, social gathering areas or sensitive installations (Zeeman, 2022).

Table 8 – Expected ground vibration at various distances from charges (Zeeman, 2022)

No	Distance (M)	Expected PPV (mm/s) for 69 kg Charge	Expected PPV (mm/s) for 207 kg Charge
1	50.0	59.1	146.4
2	100.0	30.3	75.0
3	150.0	9.7	23.9
4	200.0	6.0	14.9
5	250.0	4.2	10.3
6	300.0	3.1	7.6
7	400.0	1.9	4.7
8	500.0	1.3	3.3
9	600.0	1.0	2.4
10	700.0	0.8	1.9

No	Distance (M)	Expected PPV (mm/s) for 69 kg Charge	Expected PPV (mm/s) for 207 kg Charge
11	800.0	0.6	1.5
12	900.0	0.5	1.2
13	1000.0	0.4	1.0
14	1250.0	0.3	0.7
15	1500.0	0.2	0.5
16	1750.0	0.2	0.4
17	2000.0	0.1	0.3
18	2500.0	0.1	0.2
19	3000.0	0.1	0.2
20	3500.0	0.1	0.0

Based on the simulated results from the ground vibration evaluation for the minimum charge, boreholes 8 and 11, and the power line/pylon structures within the pit area may be at risk of damage. All other structures beyond this point presented an acceptable level of tolerance against ground vibrations. The results from the simulated maximum charge impacts on structures within the project area indicated that boreholes 8 and 11 as well as the power line/pylon structure within the mine pit area to be at risk potentially.

The nearest public houses are located 1070 m from the pit boundary. Ground vibration levels predicted at these buildings where people may be present is 0.9 mm/s for the maximum charge. In view of this no specific mitigations will be required (Zeeman, 2022).

4.8.3 VIBRATION INDUCED CRACKS

Ground vibration-induced cracks (a form of structural decay) from blast events are possible and will mostly be responsible for cracks in structures if the frequency is high enough and at constant high exposure levels (BME, 2022).

The presence of general vertical cracks or horizontal cracks that are found in all structures does not indicate damage due to blasting operations but rather damage due to construction, building material, age, and standards of building applied. Proper building standards are not always applied, and the general existence of cracks may be due to materials used rather than from blasting events.

Figure 15 is a typical example of a crack caused by ground vibrations from blasts on a brick-and-mortar structure and should be used as a reference for future crack surveys on building structures within the ML.

Figure 15 – Example of blast-induced damage

4.8.4 AIR BLAST LIMITATIONS ON STRUCTURES

A blast does generate sound but for the purpose of this study the specialist focussed only on its possible damage capability. The three main causes of air blasts are grouped as:

- Direct rock displacement at the blast; the air pressure pulse (APP).
- Vibrating ground some distance away from the blast; rock pressure pulse (RPP).
- Venting of blast holes or blowouts; the gas release pulse (GRP).

Ground vibration is experienced at different levels; BMC considered only the levels that are experienced as “Perceptible”, “Unpleasant” and “Intolerable” within the industry. This is indicative of the human being’s perceptions of ground vibration and clearly indicates that humans are sensitive to ground vibration perceiving it at levels of 0.8 mm/s as perceptible (See Figure 16).

This general guideline helps with managing ground vibration and the complaints that could be received due to blast-induced ground vibration. Indicated in Figure 16 is a blue solid line that indicates a ground vibration level of 12.5 mm/s and a green dotted line that indicates a ground vibration level of 6 mm/s. These are levels that are used in the evaluation by the specialist.

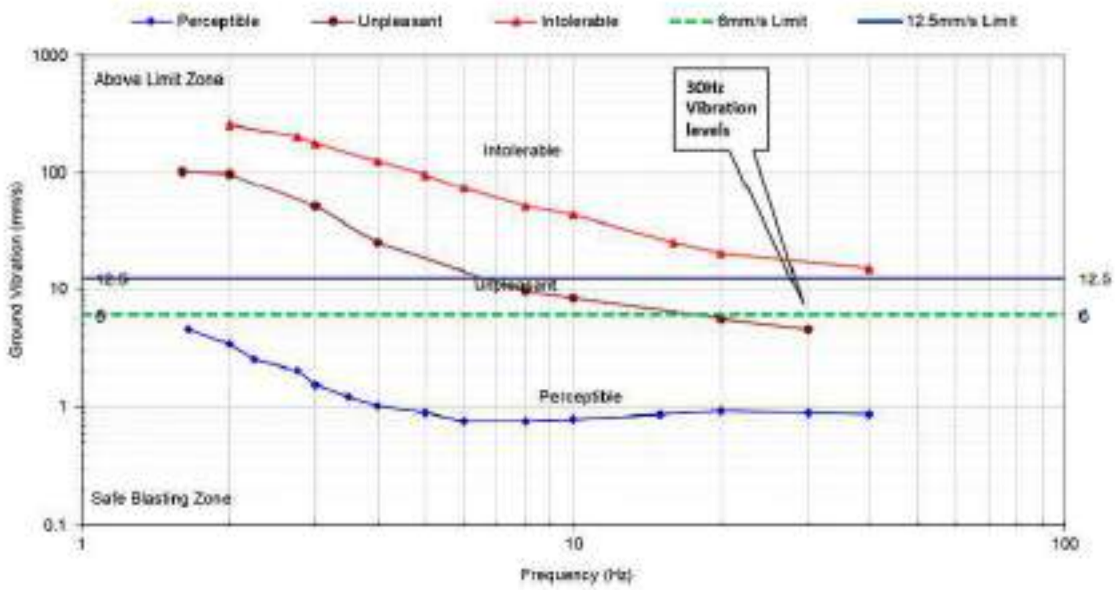

Figure 16 – Ground vibration and human perception

Generally, people assume that any vibration of a structure - windows or roofs rattling - will cause damage to the structure. An air blast is one of the causes of vibration of a structure and is the cause of nine out of ten complaints (BMC, 2022).

In the absence of Namibian standards on this aspect, the general recommended limit for air blast currently applied in South Africa is 134 dB and is used in this assessment. Based on work carried out by Siskind et al. (1980), and referenced in the work done by BME, monitored air blast amplitudes up to 135 dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies (BME, 2022).

Table 9 shows estimates of damage thresholds by air blast based on empirical data developed by Persson et al. (1994). Table 10 shows the air blast limits applied in the blast vibration study.

Table 9 - Estimate damage causing limits for air blast

Level	Description
>130 dB	Resonant response of large surfaces (roofs, ceilings). Complaints start.
150 dB	Some windows break

Level	Description
170 dB	Most windows break
180 dB	Structural Damage

Table 10 - Air blast limits applied in the study

Level	Description
<120 dB	Preferred levels to avoid complaints
120 dB	Bottom limit applied for start of complaints
128 dB	USBM Proposed Limit for Schools and Hospitals
134 dB	Current RSA Limit

The possible negative effects from air blast are expected to be the same as that of ground vibration for both minimum and maximum charges. The specialist maintains that if stemming control is not exercised this effect could be greater with a greater range of complaints or damage. The pit is located such that "free blasting" – meaning no controls on blast preparation – will not be possible. The effect of stemming control will need to be considered as mitigation against air blast effects. All attempts should be made to keep air blast levels from blasting operations well below 120 dB where the public is of concern (BME, 2022).

4.8.5 FLY ROCK

Blasting operations are typically managed in a way that facilitate the excavation process of loosened rock material in terms of scale and type. Therefore, the sought movement should be in the direction of the free face which is why the orientation of the blast is important. Elements travelling outside of the expected range would be considered fly rock. It is important that the blast contractors on site determine the safe distance boundary from blast sources before blasting occurs to avoid damage to people, animals, or property. From a technical standpoint it is important to ensure that the correct stemming type and length is used to ensure that explosive energy is efficiently used to its maximum and to control fly rock (BME, 2022).

4.8.6 NOXIOUS FUMES

Explosives used in the mining environment are required to be oxygen balanced. Fumes generated from blast events are generally nitrous oxides and carbon monoxide. These fumes are dangerous if exposure to them is above the threshold of 150 ppm or more regardless of exposure time. It has been predicted that 50% lethality would occur following exposure to 174 ppm for 1 hour (BME, 2022). UTMC should ensure complete evacuation of the immediate surroundings of a blast event within the safe boundary zone.

4.9 Drilling

UTMC drilled 26 additional drillholes in addition to historical drilling by ISCOR in the 1970s and 1980s to form a combined dataset of 177 diamond and percussion drillholes which informed the resource estimation of the Uis deposit.

Continuous drilling takes place on the mining benches within the open pits (V1 and V2) in tandem with blasting operations by an independent contractor. Drilling and blast optimisation using accurate data will assist in determining improved ore blasting outcomes. Observations of numerous oversize ore were made in October 2021 in the haul trucks and at the feed hopper to the mill crusher. A rock breaker is employed full-time at the hopper to manage the oversize material. Improvements in terms of ore size could be achieved with drilling and blasting adjustments.

4.10 Haul roads

The available space within the pit was used for safe haul roads wherever possible instead of expanding the pit walls. The haul road width was reduced at the lower levels of the pit to minimise waste stripping as much as possible. The exit positions of the ramps were determined based on the proposed positions of the primary crusher and the waste co-disposal facility (DFS, 2021). The surface haul roads are dual directional separated by a course gravel-based island. The width of one lane (18 m) is wide enough to accommodate the width of the largest mobile plant on site i.e., a 40t tipper truck.

It is not envisaged that the ramp to surface haul roads will need additional protective measures to ensure stability whilst in use. Haul road dust suppression is conducted for the Project and is handled through a comprehensive dust management system.

4.11 Materials handling and concentrating plant

An optimal site layout is based on designing the site around critical landform features such as topography and sensitive areas while considering the efficiencies required for the mining operation. Optimal use of available space was considered in the placement of additional comminution and processing infrastructure.

The current processing plant is strategically placed to allow ore throughput of 80 tph. The anticipated expansion required to increase production volume to 120 tph will not require the Plant to relocate but be modified.

The position of the current Plant illustrates the limited spatial extent to which the modifications will be applied to accommodate the tantalum circuit. The petalite beneficiation circuit within the bulk sampling, sorting, and testing facility will be placed west of the current tin processing plant and will contain its own materials handling section and related infrastructure.

4.11.1 COMMINUTION AREAS

The existing processing plant consists of a comminution section and a concentrator section. At the start of the concentrating section, ore is screened into a coarse fraction (larger than 0.65 mm) and a fine fraction. Crushing to a top size of 6.4 mm is done in four stages. From the primary crusher, ore is conveyed to the primary stockpile, from where it is fed to the secondary crushing plant, in which the ore passes through another three stages of comminution (DFS, 2021).

The bulk sampling, sorting, and testing facility will have its own dedicated comminution area that consists of a ROM tip pad and a primary crusher before being fed to the preparation area for secondary crushing, classification and thereafter milling and recovery.

4.12 METALLURGY AND PROCESSING

4.12.1 TIN AND TANTALUM PROCESSING

Other than ferrosilicon (FeSi) for dense media separation (DMS), no chemicals are used in the tin and tantalum ore beneficiation process. The recovery of FeSi media for reuse is a critical aspect of effecive DMS. The process plant employs four-stage crushing followed by gravity concentration (pre-concentration, concentration, and scavenging). The coarser fraction is processed with DMS and the finer fraction with scavenging spirals. Concentrates from the DMS and spirals are cleaned on a shaking table to separate the heavier dense metals from the waste rock granules. Discards (waste rock granules) are dewatered and co-disposed with mine waste rock. Coarse and fine tailings are dewatered on vibrating screens, while slimes are dewatered through a thickener and filter press combination. The recovered water is reused in the process. Dewatered tailings are co-disposed with mining waste rock (DFS, 2021).

The following changes are envisioned to be made to the process flow in various sections of the plant as part of the additions under the Phase 1 Stage II development:

- A crusher and screen to be added to Area 100 in feed preparation.
- A stockpile has been added between crushing and beneficiation in Area 300.
- Densifier capacity has been increased in Area 320.

- The medium circuits for DMS2 and DMS3 have been combined to improve operability of DMS3 and maximise Sn recovery from DMS2 floats.
- The DMS2 floats re-crush circuit has been converted to a closed circuit in Area 350. In addition, bins have been added before roll crushers to improve operability.
- Additional spirals to re-process middlings will be installed in Area 440.
- An additional shaking table will be installed to improve capacity and the shaking tables will be relocated. The shaking tables will be replaced with ones with higher separation efficiency.

A simplified summary of the plant flow diagram of the Stage II process is shown in Figure 17.

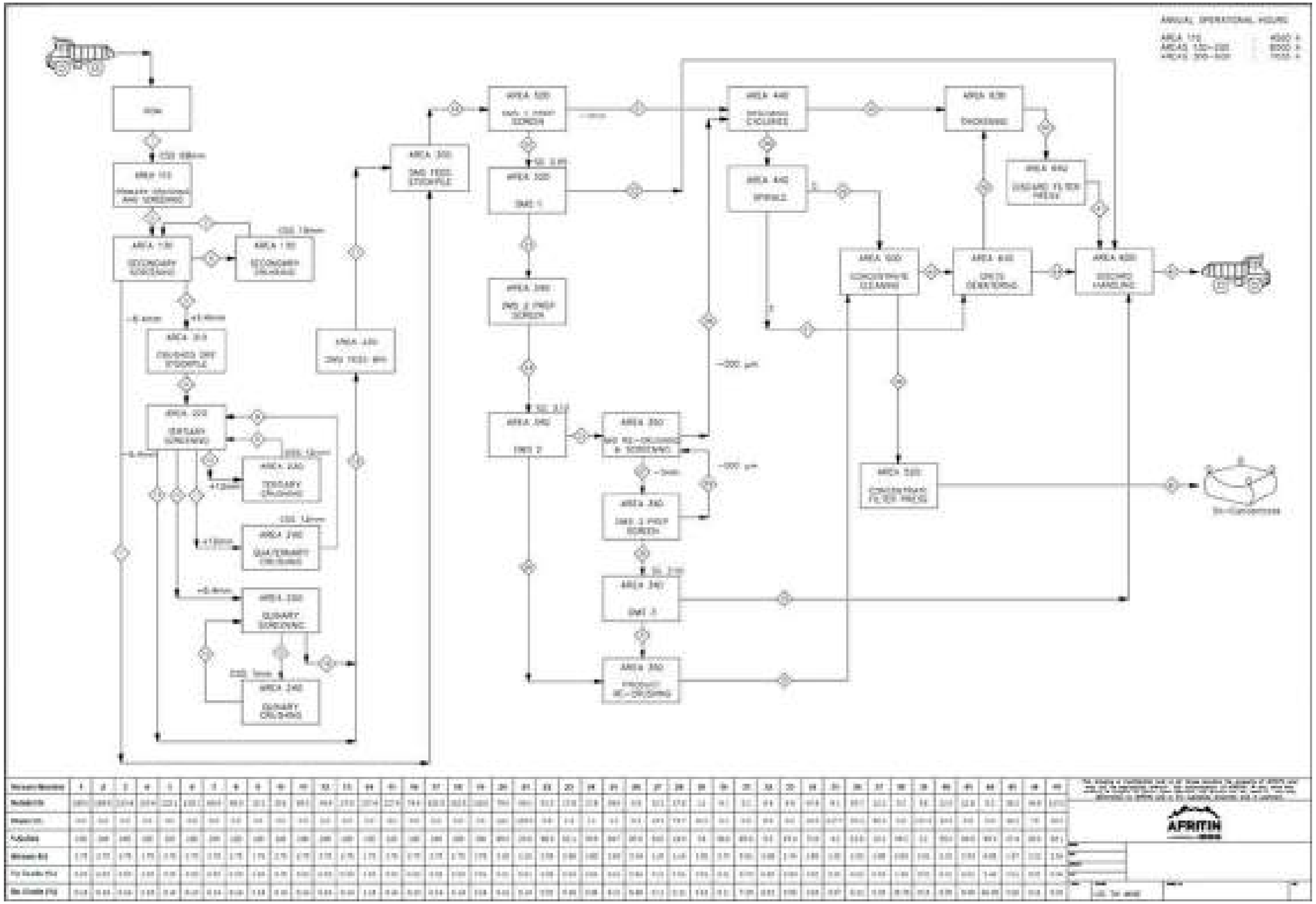

Figure 17 - Flow diagram of processing methodology

4.13 BULK SAMPLING, SORTING, AND TEST FACILITY

4.13.1 ROM PAD

The ROM pad will be constructed to accommodate the ore required for bulk sample processing. Access to the ROM pad will be via the existing haul road (for material from the current mining pits), or a separate heavy vehicle haul road for external material. The maximum size of a sample to be processed through the facility in a single campaign will be approximately 2000 tons, which will be placed on the ROM pad prior to processing.

4.13.2 METALLURGICAL SUPPORT FACILITY (SAMPLE PREPARATION)

The material will be moved from the ROM pad to the MSF using mobile earth-moving machinery. The purpose of the MSF area is to prepare the bulk sample into the relevant particle sizes for the testing intended to be undertaken. This area will be equipped with a primary and secondary crusher and two screens with which to crush and classify the material. In addition to mechanical crushing and screening, the area will also have two sensor-based sorters which include an XRT sorter (which sorts material based on particle atomic density) and a near-infrared sorter (which uses broad spectrum light wavelengths in the sorting process). This has the potential of achieving waste rejection early in the beneficiation process and increasing the feed grade to the lithium concentrator.

4.13.3 BULK SPLITTING AREA

The purpose of the bulk splitting area will be to split the sample to be used for test work and analysis.

4.13.4 LITHIUM PROCESSING (FUTURE ACTIVITY)

Andrada's anticipated lithium pilot petalite flotation plant will be designed to produce 20 tph concentrate (Figure 18). The lithium pilot plant is considered to be a material change to the Plant under consideration in this document, and an addendum to this ESIA will need to be initiated if a decision is made to go ahead with this process.

The following are the design parameters for the Plant:

- 20 tph feed;
- 16 – 20% DMS yield to floats, and
- Module to consist of a feed reception and feeding arrangement, DMS, milling flotation, WHIMS magnetic separation, filtration, and water reticulation sections.
- The flotation circuit will comprise flotation cells and associated equipment which will include conditioning tanks, dosage pumps, etc. The circuit will be equipped with acid neutralisation facilities where the HF and H2SO4 are used as reagents.

This flotation requires reagents that are grouped broadly as follows:

- Modifiers – the creation of suitable pH conditions and control (acids or alkalis).
- Activators – create improved conditions for absorption of collectors on mineral surfaces.
- Collectors – make the valuable minerals non-wettable with water (hydrophobic).
- Depressants – make certain minerals (unwanted minerals) wettable with water (hydrophilic).

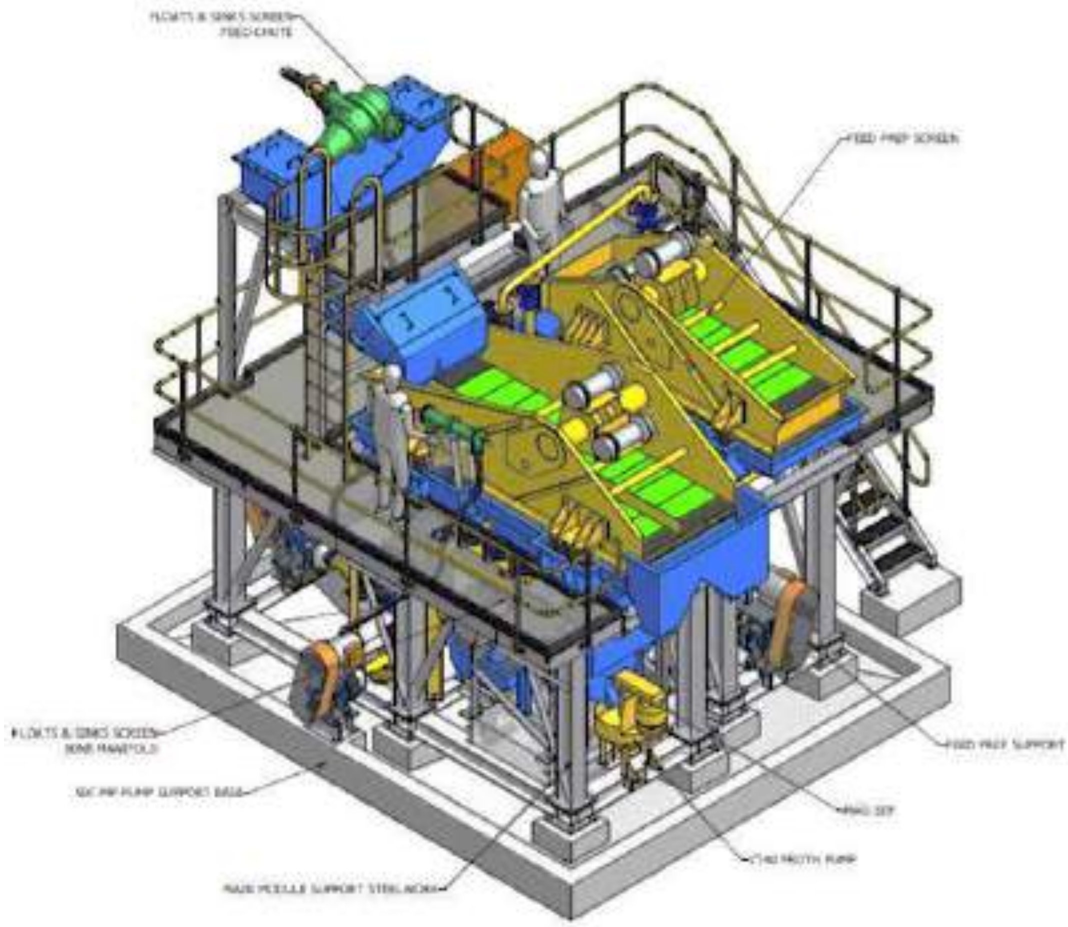

Figure 18 - Schematic diagram of the petalite beneficiation plant

To prevent the potential spillages of the acids, the floatation circuit will be within a well-ventilated, enclosed room with a concrete floor. The lithium-bearing material will first be milled and de-slimed (including attrition) before the de-slimed material is fed into the flotation plant. For the petalite concentration for lithium extraction, the main reagents will be hydrofluoric acid (HF) as the collector at total dosages of approximately 8kg per tonne of feed material and sulphuric acid (H2SO4) as the modifier at dosages of 5kg per tonne of feed material. It is envisaged that approximately five tonnes of HF and 1.5 tonnes of H2SO4 will be stored at any one time on site. From this stored acid reserve on site the below quantities represent the total acid dosages for the flotation part of the process:

- 4.7 kg of H2SO4 per tonne of flotation feed, and
- 8.2 kg of HF per tonne of flotation feed in all stages.

At this early stage of the design process, it is anticipated that approximately five tonnes of HF and three tonnes of sulphuric acid will be required for lithium extraction in the petalite plant. The result would be that approximately 300 tonnes of the lithium-bearing product will be produced from each sampling and testing campaign.

The use of these chemical reagents will require stringent handling and waste management protocols. The two acids used in the beneficiation plant are hazardous, with HF being extremely dangerous. The make-up and dilution of these acids at the industrial level require expertise and operators to be fully trained to satisfy competency requirements. Infrastructure to accommodate this process will need to be designed, constructed, and established to recognised best practices and or international standards for the use of these chemicals. Therefore, the Proponent also intends to develop a waste neutralisation plant within the bulk sampling, sorting, and test facility to neutralise acid-bearing slurry before final disposal onto the existing waste rock dumps.

4.13.5 ACID NEUTRALISATION

Design for neutralisation of the acids will be done by an identified expert. However, in principle, the slurry containing the acids in both the concentrate and waste streams will be neutralised by the addition of lime (Ca (OH)2) or soda ash (Na2CO3) in a tank containing hydrofluoric acid (HF) contaminated slurry before the material is pumped to respective dewatering circuits. In the filters clean water will be circulated through the filter press (in both concentrate and discard) to wash the filter cake and dilute any residual contamination. The filtrate further undergoes pH measurement to ensure pH is in the range 6-8 before recirculating as process water. The filter cake is dried and stored (concentrate) whilst the discard filter cake is potentially discarded onto the current waste dump. Caustic soda (NaOH) will be used for the neutralisation of sulphuric acid in basically the same way as the HF is neutralised (Andrada, 2022).

4.13.6 LITHIUM-BEARING WASTE MATERIAL

The neutralised discard will undergo geochemical testing (kinetic leach testing) before disposal. This will determine the success of the neutralisation process. Until results are obtained from the test work, the filter cake discard material will be stored in a suitably bunded area and treated as a highly hazardous material. Only once the results from the test work are received, will the mine be able to plan an appropriate waste disposal strategy for the material.

4.13.7 GASEOUS EMISSIONS

In addition to particulate matter and TSP classed as fugitive sources that will be generated by the facility, an additional class of emissions are expected to occur from the lithium beneficiation plant from point sources including residual HF vapours and sulphuric acid fumes, that could be generated by the plant during its operations and potentially escape from any point within the circuit into the environment. For example, sulphuric acid is a highly reactive and volatile compound that will form flammable hydrogen gas when in contact with water, whilst hydrofluoric acid vapours could be fatal when inhaled as a vapour in excessive volumes. The Proponent will need to align its operational capacity with the IFC Environmental, Health and Safety Guidelines for mining which contains recommendations for OHS management inclusive of air quality management under Section 1.2. to manage this aspect The Proponent will therefore develop a separate occupational, health, and safety plan to manage the storage, use and emissions prevention of acid-based substances from the facility, given the fact that it intends to certify itself as ISO compliant. In this regard, the ISO 45001 standard can be of significant benefit to the company when pursued.

4.13.8 CHEMICAL STORAGE

All chemicals used in the process will be stored in a cool, dry, well-ventilated bunded chemical store constructed to the required international safety specifications for the storage of such substances used to prevent potential structural failures. The storage area will also be subjected to approved safety and emergency response procedures approved by the relevant competent authority. A separate offloading and storage area will be constructed for the HF that will also conform to all safety protocols of an international standard. It is expected that five tonnes of HF will be used per month, and hazardous materials procedures will be used for the offloading, handling, storage, and use of HF. The standard HF storage tanks are made from either carbon steel, stainless steel, Monel or Polytetrafluoroethylene (PTFE). The tank walls thin over time and regular condition monitoring needs to be conducted (Andrada, 2022). The average tank's lifespan is +approximately four years and must comprise a three-layer containment infrastructure to mitigate and manage potential de-containment.

The chemical storage area will include all required emergency equipment, including safety showers and eyewash stations, and material safety data sheets for all onsite chemicals. Dispensing of the reagents to the flotation streams should take place in closed circuits with dosing systems to control the dosing rates. The Proponent will follow the internationally accepted cyanide management code as guideline for the design and construction methodology of unloading, storage, and mixing facilities consistent with sound, accepted engineering practices, quality control and quality assurance procedures, spill prevention and spill containment measures.

4.13.9 WATER AND WASTEWATER INFRASTRUCTURE

Plant water will be sourced from the mine's current supply borehole network and stored in a reservoir. At the completion of the design for the processing plant, the total required water demand will be finalised. However, the mine intends to utilise a closed-loop water circuit with limited environmental discharge. Raw water can be used in the processing of certain minerals; however, raw water will also be fed into a reverse osmosis plant to ensure optimal water quality for certain plant processes. Potable water will be supplied to the change house and administration offices from NamWater sources. Sewage will be disposed of using a wastewater package system or a French drain system. Stormwater management infrastructure will be constructed to ensure that clean water is diverted around the site, and stormwater within the site is controlled.

Water from the thickener will be diverted to the new settling pond. Water will overflow into the new water return pond (estimated maximum 200 m3 per day for short intermittent periods) and slurry remaining in the settling pond will be excavated out and placed onto the waste rock dump. The water return pond will be lined with clay and an HDPE liner. Water in the water return pond will be recirculated back into the processing plant for reuse. Note it is planned that a second filter press is to be installed to reduce the amount of water from the thickener that will be required to be dumped and thereafter the water return pond will be used collection pond in case of emergency situations.

Figure 19 - Uis Tin Mine with the indicated infrastructure upgrades required for Phase II. Green indicates the impact area for future operations. Pink indicates the new sewage plant (Bio-Mite). Purple indicates the newly planned water return pond. Red indicates the newly planned settling pond and canal (Source: Uis Tin Mining Company (Pty) Ltd).

4.13.10 OFFICE AND CHANGE HOUSE

An office and change house will be located onsite (Figure 20). The change house will contain emergency response facilities designed to protect human health as a first response facility in the event of worker exposure to dangerous chemicals.

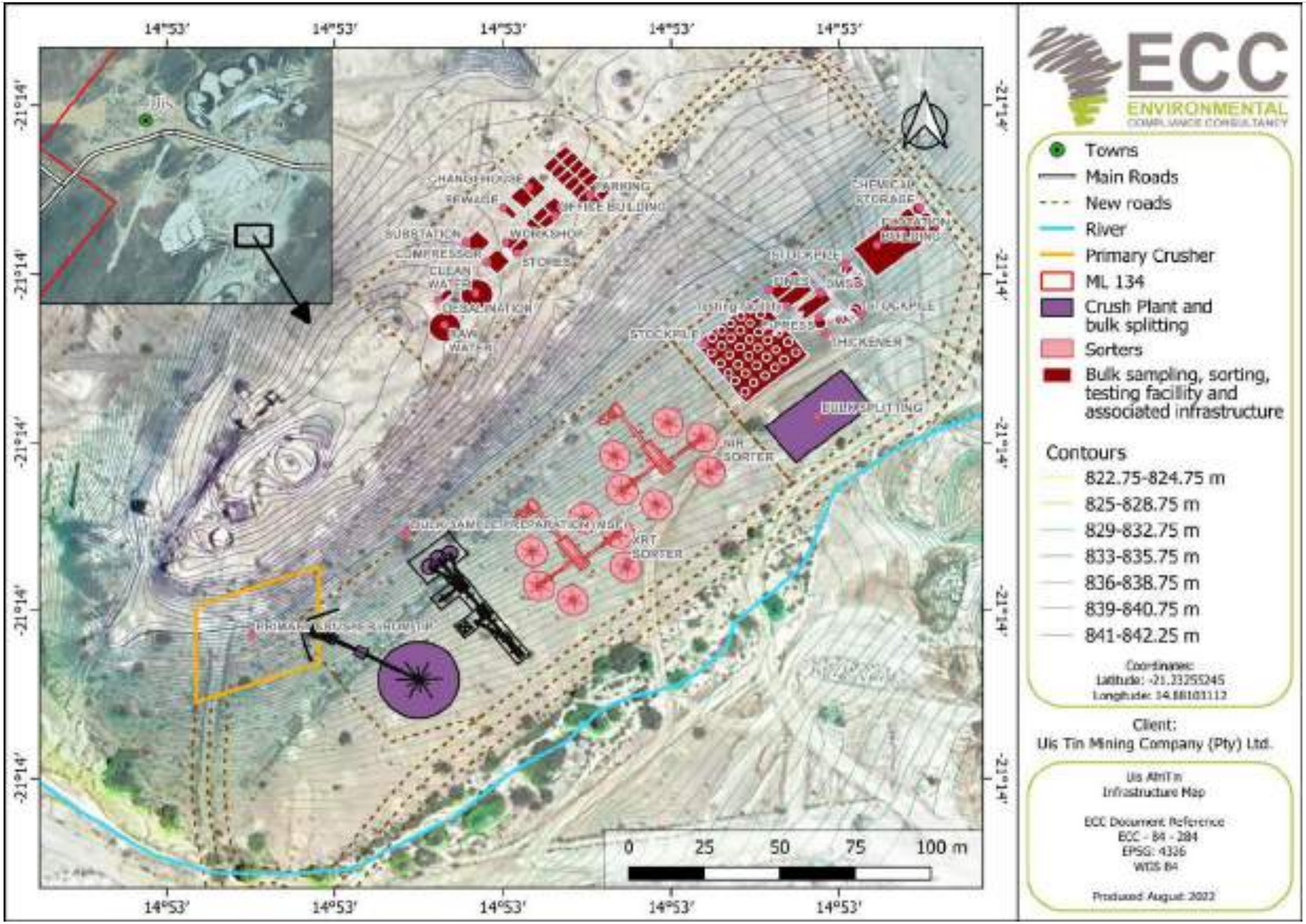

Figure 20 - Bulk sampling, sorting, and testing facility and associated infrastructure

4.14 SUPPORT INFRASTRUCTURE AND SERVICES

4.14.1 ONSITE OFFICE BLOCKS

The mining office block is a modular structure installed on a mesh reinforced concrete slab. The building provides office space to technical personnel, including the process manager, the technical services manager, geology personnel, surveyors, maintenance engineers, the HSE team and mining support staff. The building has a meeting room, male and female ablutions, a kitchen, shaded canteen area, a pit control room, a first aid room, and an open quadrant used as seating space for personnel.

A fully-fledged and functional office block will be established as part of the design criteria for the bulk sampling, sorting, and testing facility to ensure efficiency of operations and management of the facility.

4.14.2 UTMC WORKSHOP AND WAREHOUSE

The mining warehouse (or stores) is a steel sheeted high wall structure. The warehouse is used for the storage of all critical and operational spares, as well as office and other consumables. Goods will be received by the stores personnel through the east-facing receiving bay prior to storage in the main building. Access to the store building is limited to store personnel. Acetylene gas, oil, paint, and other flammable materials

4.14.3 HEAVY MOBILE EQUIPMENT WORKSHOP

The heavy equipment workshop is managed by Nexus-Ino which is the main workshop for the maintenance and rebuilding of mining equipment. The building design is capable of handling maintenance work for all mining and support equipment as per the maintenance plan. The structure is steel sheeted on the sides supported on concrete plinths, with modular container offices. The workshop is bunded with an internal drainage system into a suitable hydrocarbon collection and treatment system. This facility is also used to maintain light vehicles used on site. One wash bay is available for equipment, before, during and after maintenance, and therefore settling dams/ponds are installed as part of the wastewater treatment system in the wash bay.

4.14.4 FUEL FACILITY

Diesel for mine operations is contained in a designated and designed site fuel facility. The fuel service provider has erected infrastructure and facilities for the storage and handling of fuel. The service provider is responsible for the supply, delivery, and management of stock for the life of mine. The Proponent does ensure the facility has the required installation certificates prior to commissioning the fuel facility and is audited monthly for operational compliance.

4.14.5 EXPLOSIVES MAGAZINE

The appointed contractor, BME, based in Arandis, provides explosives and blasting services to the mine on the day of blasting. The contractor has established and is responsible for its satellite explosive magazine infrastructure, located next to the Big Dog and Nexus-Ino shops. Space provision was made for both sites, and the proper siting of the explosive magazine will be re-assessed to ensure it is in conformance with the requirements of the Namibian Labour Act, Namibian Mining Legislation, and Regional Explosives Standards or regulations.

4.14.6 COMMUNICATION

Radio, telephone, and internet connections are already functional for the mining operation. Communication infrastructure, including masts, is installed.

4.15 UTILITIES

4.15.1 POWER SUPPLY

A 1,500 kVA supply agreement was signed with NamPower, with a 66 kV supply take-off from the Uis NamPower substation. A 1 km approximate extension to the existing substation was constructed, with the associated switchgear, metering, and a 66 kV feeder bay. A 66 kV overhead line feeds an existing 66/11 kV substation situated outside the safe blast radius of the open pit mine, close to the current plant area. The capacity of the 66/11 kV transformer is 2,000 kVA, with a protection circuit breaker in the 66 kV circuit. See Figure 21.

Figure 21 - Main power supply off-take (Source: ECC, 2021)

4.15.2 STAND-BY POWER

Standby power supply consists of two 635 kVA containerised Perkins and one 600 kVA MAN diesel generating sets. These are installed in the power station area, and power from each is fed onto a common generator busbar. An automatic centralised synchronisation controller, that interfaces with the individual generator control panels, will allow for the switching and running of the generators in parallel. The standby power station has the capacity to supply the full backup power requirements of the processing plant. The standby power generating sets is illustrated in Figure 22 (DFS, 2021).

Figure 22 - Genset stand-by power source (Source: Minxcon, 2021)

4.15.3 WATER SUPPLY

Phase 1 of the operation sources its water supply from within the Ugab catchment area, utilising the Uis River alluvial aquifer system through supply boreholes in the Uis River channel. The current mine design indicates a water requirement for Phase 1 Stage I to be between 10 m3/h and 15 m3/h, but actual water consumption exceeds 20 m3/h. The stage water demand throughout the life of mine duration is calculated at 18.1m3/hr. Borehole water levels are monitored monthly to keep track of the utilisation of the water source and to manage its sustainability. The largest water demand occurs at the start-up of the tin-tantalum plant, as the facility is run on water only, this demand is then reduced with the feeding of the ore into the plant (DFS, 2021).

The abstraction of groundwater from existing boreholes is permitted under two abstraction permits issued for industrial (mining) purposes by the Ministry of Agriculture, Water and Land

Reform (MAWLR) since 2019. The previous total allowable abstraction volume from boreholes of 75 000 m3 per annum was recently increased to a total volume of 150 000 m3. The borehole locations are presented in Figure 23.

Process water is supplied from well-fields and an open-pit lake (K5) north of the mining area through a pipeline network. Raw water is pumped into a 1,000 m3 bulk reservoir located at the process plant, from where make-up water is pumped to another 250 m3 process make-up water tank, close to the wet part of the plant. This is not potable water.

Potable water to the production areas is supplied through a 60 mm municipal water-supply pipeline that was installed during construction. This water is not used for processing needs (DFS, 2021).

The Digby Wells study conducted determined that the supply of the operations from existing sources is sufficient to sustain the expansion operations of stage II (2022)(Digby Wells, June 2022). Further details are contained within Section 5.9.3.

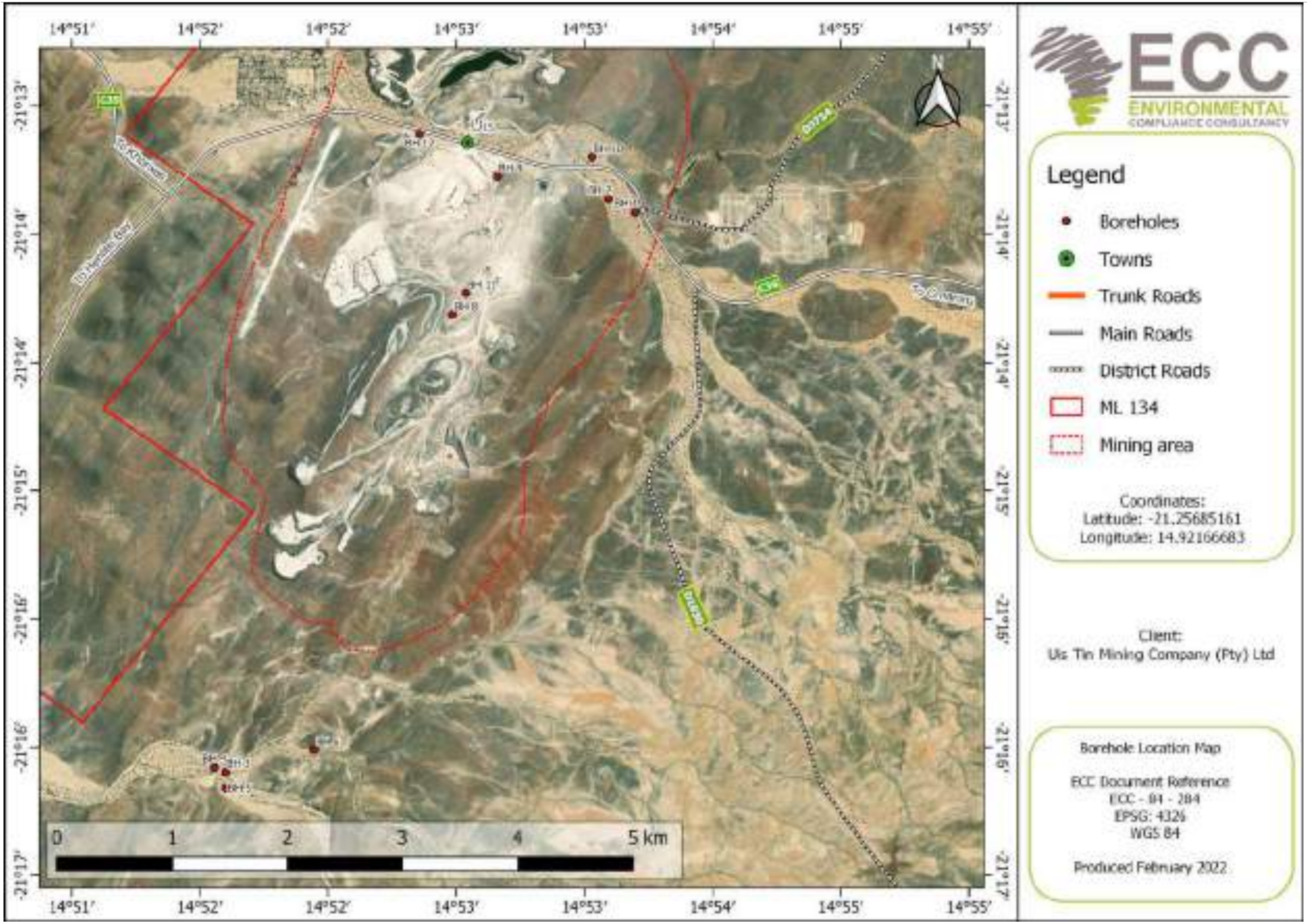

Figure 23 - Borehole locations

4.15.4 WATER DEMAND

As per Digby Wells, June 2022, the Uis Tin Mine pilot plant is currently producing ~65 tonnes of tin concentrate per month for Phase 1 Stage I, with a water demand of ~0.288 Ml/day (12 m3/hr). The expansion of the pilot processing plant to Phase 1 Stage II will increase production at the mine to ~100 tonnes of tin concentrate per month, which will increase the water demand of the plant to ~0.432 Ml/day (18 m3/hr). Water is currently sourced from water supply boreholes in the Uis River channel as well as contributions from water stored within the K5 pit and this investigation assesses whether the water supply boreholes can meet the increased demand for the planned 18-year Life of mine of the Phase 1 Stage II expansion.

A later Phase 2 expansion plans to increase production to ~1 250 tonnes of tin concentrate per month.

Water supply for the Project is proposed from a combination of surface, groundwater and desalination sources and evaluated from supply optimisation studies conducted by Digby Wells. See Section 5.9.3. The existing Ralf's pond and Bleedwater pond will be replaced by a settling pond and return water pond in 2023.

4.16 MINERAL AND NON-MINERALISED WASTE

4.16.1 WASTE ROCK

The proposed waste dumps are located northeast and northwest of the open pit, as shown in Figure 7. The site has three separate dumps which can store an estimated total of 26.66 Mm3 of waste rock and plant waste fines: A (8.75 Mm3), B (14.82 Mm3) and C (3.09 Mm3). This is a 10% overcapacity when compared to the LoM co-disposal volume requirement of 23.85 Mm3 (DFS, 2021).

The current mine plan, taking the 15 Mt pit design into consideration, will produce a total of 23.9 Mt of waste rock and 14.7 Mt of dewatered plant waste fines over the LoM. Dewatered plant waste fines are co-disposed with mining waste rock on a co-disposal facility (DFS, 2021). The co-disposal facility has capacity to be expanded upon and will be used to store Stage II waste rock and plant waste fines (-8mm grain size and clay content). The DFS outlines and describes the design and operating philosophy behind this operation. The parameters taken into consideration are:

- The angle of repose of the outer slope to be 36° for each 20 m lift and a minimum rock crest width of 10 m. This will provide a stable outer shell of waste rock that is erosion-resistant.
- Waste rock and plant discard are placed in 2.5 m wide rows on top of the co-disposal dump and mixed by mining equipment which ensures slope stability and internal void filling.
- Rainwater penetrating the waste rock facility is free of any acid mine drainage and contaminants which eliminate the requirement for settlement ponds and pollution control

water ponds downstream from the co-disposal dumps. Interior paddock embankment slopes ranging from 2.5 H: 1 V to 1.5 H: 1 V 10 m high lifts with 5 m wide benches between lifts. This approach will establish an overall slope angle of 3.5 H: 1 V.

The appropriate waste dump volume requirement of 13.92 Mm3 and the overall plant waste fines dump volume requirement is 9.93 Mm3 (DFS, 2021).

Rehabilitation requirements are considered in dump location and design, and all dumping areas will undergo an ore sterilisation campaign prior to waste dumping. The waste rock dumping strategy is to reduce the hauling distance and similarly enable progressive rehabilitation of the waste dumps wherever possible. In-pit dumping has not been considered for this stage. Waste dumps will be sloped to 3:1 near the top and 4:1 at the bottom covered with finer material. The mine will promote natural vegetation regrowth on the dump shell as opposed to active revegetation. The co-disposal facilities should be re-sloped in this manner as soon as possible in a progressive rehabilitation program. The shallow slopes provide increased stability should the increase fines content create problems with pore pressures. The approach is designed to maintain a low phreatic surface, as noted above.

4.16.2 POTENTIAL ACID ROCK DRAINAGE

UTMC operates two waste rock dumps (V1 and V2) in the form of co-disposal facilities as described above. The tailings produced from this process are currently being disposed of on the V1 and V2 waste rock dumps (WRD) along with the waste rock material extracted from the V1/V2 open pit. To establish the quality of in-situ water infiltrated through the current waste material, water samples were collected from the toe of both waste rock dumps after the heavy rainfall events in February 2022. The results indicate that the runoff from these dumps are compliant to the IFC effluent discharge limits (2007).

ECC is conducting geochemical and kinetic leach tests to confirm the long-term potential for acid drainage and metal leaching.

4.16.3 CONCEPTUAL ACID MINE DRAINAGE RISK FROM THE PETALITE FLOTATION CIRCUIT

In addition to the tin-tantalum processing, Andrada is investigating the addition of a flotation circuit to the bulk sampling, sorting, and testing facility for the processing of petalite. This process will involve milling, froth floatation, and dewatering to produce petalite concentrate and waste discard material. The petalite processing is likely to include the use of sulphuric and hydrofluoric acids as well as sodium chloride (NaCl) and potassium chloride (KCl) brines in the flotation circuit. The tailings material generated from processing the petalite has not been geochemically assessed but based on the XRF results of the DMS floats sample, the tailings materials could comprise of quartz, albite, orthoclase, muscovite, cookeite and clay minerals. These are expected to be non-acid forming minerals. However, the use of acids in the processing circuit could potentially mobilise metals and metalloids. The tailings material will be neutralised and dewatered before being deposited on the V1 and V2 WRD facilities. The water will be recycled back to the plant (Digby Wells, 2022).

4.16.4 CONCEPTUAL CONTAMINATION PLUME MODELLING

As a geochemical assessment of the tailings material has not been undertaken as yet, Digby Wells simulated a plume for Total Dissolved Solids (TDS) using a percentage rating to provide the Proponent with the potential flow paths and extent of the conceptual contamination plume, should one develop from the V1 and V2 WRDs, see Figure 24.

The following assumptions have been incorporated into the numerical for the contamination plume scenario: The numerical model setup is described in the hydrogeological report by Digby Wells, dated June 2022;

- It is assumed that abstraction from the Uis mine water supply boreholes will cease pumping at the end of Life of Mine (LoM), allowing the groundwater levels to recover;
- The daily abstraction for the Brandberg Rest Camp borehole was assumed as 200 m3 /d, and 100 m3 /d for the NamClay borehole. It is understood that the abstraction from the Brandberg Rest Camp is only expected to continue for the next 18 months, however the assumed abstraction values for both third party boreholes were modelled for the duration of the Life of Mine and 100 years post closure as a worst case scenario;
- The contaminant plume scenario was simulated using the combined 127 440 m3 /a abstraction yields for the Andrada water supply boreholes. This abstraction yield was chosen to represent a conservative approach in the model as the lower yields would recover quicker allowing the potential contaminant plume to migrate from the WRD sooner (compared to the previously simulated sustainable yields. Please refer to the Additional Modelling Scenario memorandum by Digby Wells, dated October 2022);
- The WRDs were assigned a recharge potential of 20% MAP for the LoM;
- Based on the closure strategy provided below, the WRDs are assumed to have a recharge potential of 15% MAP for the post closure.
- The Total Dissolved Solids (TDS) concentrations were applied to the WRDs for the duration of the project life and for 100 years post closure. This was taken as a conservative approach in the model due to the lack of geochemical information; and
- The TDS concentrations was applied to the third layer in the model (which was the first saturated layer in the numerical model). This approach allows for a worst-case direct infiltration into the groundwater scenario, as in reality the contaminant would be transported through the unsaturated zone allowing for interactions, dispersion, advection and diffusion to reduce the contaminant concentration prior to reaching the groundwater aquifer.

The closure strategy for the WRD is as follows:

- Reshape the side slopes to 1:4 gradient and revegetate passively;
- Remove deposition systems and ponded water will be drained or dried;

- A berm (approximately 5 m wide and 1.5 m high) will be constructed around the top of the WRD to contain storm water from overtopping onto the side slopes of the WRD;
- Berms (approximately 1 m and 1 m high) will be placed in a crisscross pattern across the top of the WRD to form 50 x 50 m paddocks. The aim of these paddocks is to act as evaporation ponds and evapotranspiration sinks (when vegetation is established) to manage storm water and wind erosion; and
- The upper surface of the WRD will be revegetated passively.

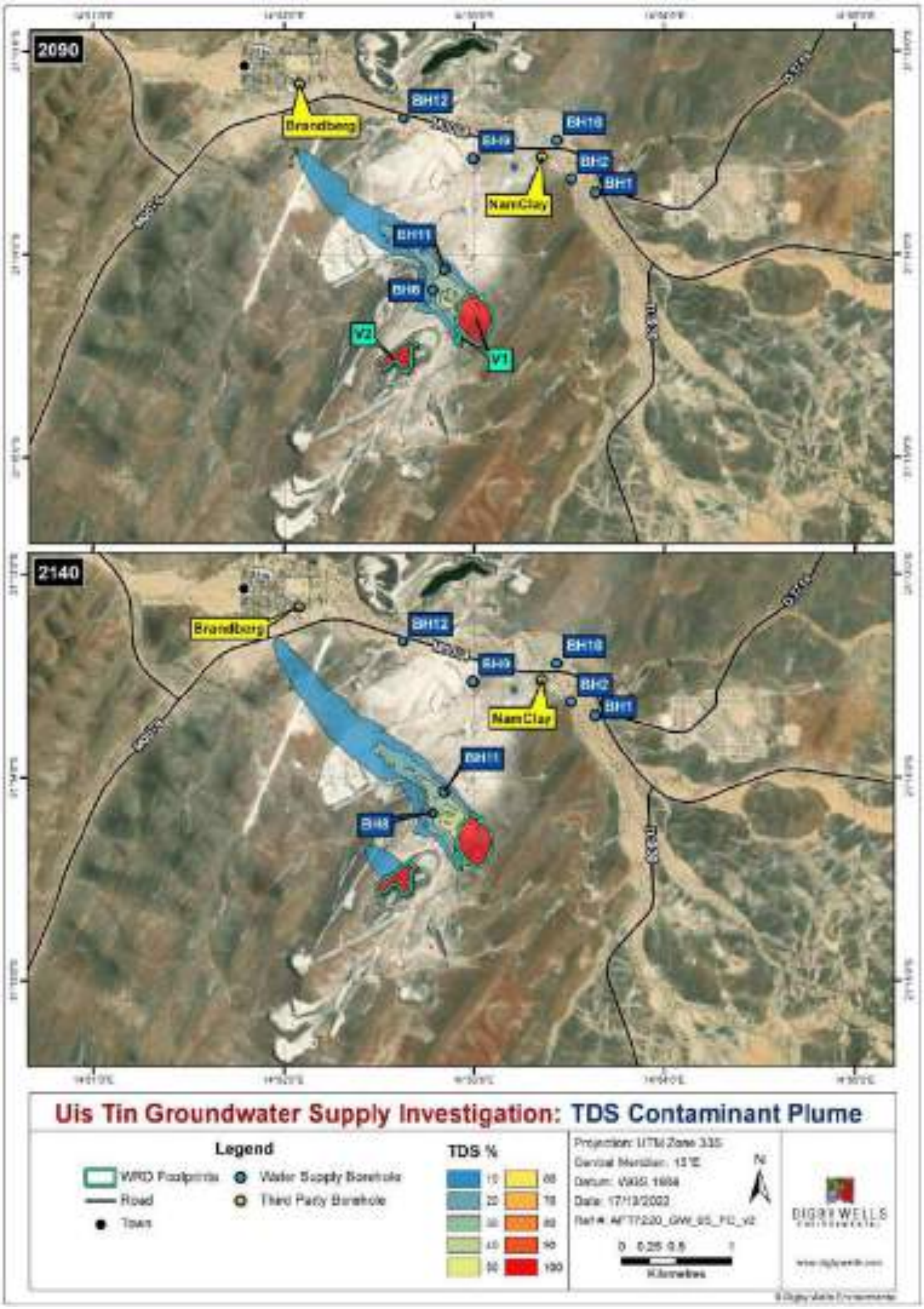

Figure 24 - Contamination plume at Year 2090 and 2140

4.16.5 INTERPRETATION OF THE CONTAMINATION PLUME MODELLING RESULTS

The simulated contaminant plume for the V1 and V2 WRD's are shown for 50 years post closure (the year 2090) and for 100 years (the year 2140). It is assumed that the general direction in which a contaminant plume will follow from the V1 WRD will is northwest for the project towards boreholes 8 and 11. This is as a result of both the natural gradient that falls toward the northwest and the active abstraction from borehole 8.

Based on the numerical model simulations, a 10% increase in TDS is expected to reach approximately 2 km downgradient of the V1 WRD by the year 2090 and 2.4 km by the year 2140. The Uis Wellfield boreholes are located approximately 500 m to the north-northeast of the V2 WRD and therefore have less of an impact on the migration of a plume from V2 WRD in comparison to the V1 WRD. Based on the numerical model simulations, a 10% increase in TDS is expected to reach approximately 350 m downgradient of the V2 WRD by the year 2140 (Digby Wells, 2022).

The third-party boreholes at the Brandberg Rest Camp and NamClay are not expected to be impacted by the 100-year post-closure contaminant plume (with a 10% increase in TDS). However, should the abstraction volumes for the third-party boreholes increase from the assumed model volumes the contamination plume impacts to these boreholes will need to be reassessed (Digby Wells, 2022).

Once the geochemical information from the waste samples is available the contamination plume model will be updated accordingly with new source input data of the reagents used in the petalite flotation circuit.

4.16.6 GENERAL WASTE

Waste is separated at source, stored in a manner to avoid discharge of contaminants to the environment, and either recycled or reused where possible. On-site facilities will be provided at a dedicated waste storage facility for sorting and temporary storage prior to removal and disposal to appropriate recycling or disposal facilities off-site (Windhoek for general waste and Walvis Bay for hazardous waste).

Industrial waste will be sorted on-site and disposed of at appropriate facilities. Hazardous waste includes, but is not limited to, the following: fuels, chemicals, lubricating oils, hydraulic and brake fluid, paints, solvents, acids, detergents, resins, brine, solids from sewage, and sludge. A waste specification will be developed and included in the EMP.

4.16.7 EFFLUENT AND WASTEWATER

Project-generated sewage is collected and uses gravity reticulation via buried sewer pipes and transported to the new BioMite sewage treatment facility. Sewage is treated in this purpose-built sewage treatment plant. Prior to the ESIA being conducted, the old Clarus system had not been operating effectively and was replaced after UTMC commissioned a root cause analysis of the capacity issues and requested an upgraded sewage treatment facility. The water output from the plant will be suitable for use in dust suppression, vehicle washing, irrigation, fire suppression water, and process water.

The wastewater treatment plant produces a small quantity of sludge, which will be dried in a sludge-drying bed located at a point lower than the plant. Dried sludge could be used as fertiliser for rehabilitation of mining landforms.

4.17 WATER SUPPLY ALTERNATIVES CONSIDERED

The primary alternative to be assessed is the water supply for mining operations in Stage II.

All the available water supply boreholes for the Uis Tin Mine were assessed and will be required to meet the water demand for the Phase 1, Stage II requirements, the following alternative options can be considered:

- Andrada plans to dewater the K5 pit which contains an estimate volume of 190 634 m3. The timeframe for this has not been confirmed but it is recommended to plan this as far in advance as possible to reduce discharging the stored water to the environment and accommodate any dilution of the pit water may be required. The pit water has higher concentrations compared to the groundwater aquifer as a result of evaporation, which may limit its use in the plant unless this can be diluted;
- Andrada could consider establishing a covered water storage area nearby to the plant, with a minimum capacity of 1 week (~2 700 m3) supply for emergency water supply;
- There are potentially three boreholes located within ~13 m of the mine, which could be located and tested for an additional water supply to the mine and to assist with downtime associated with maintenance on the water supply boreholes. The estimated yield from these boreholes could provide an additional 23.7 m3/hr for the project but this would need to be confirmed;
- Should the above borehole not be located, it is recommended that Andrada establish additional water supply boreholes for emergencies or to allow flexibility on the current water supply network. These should preferably be outside the Uis River Catchment to reduce cumulative drawdown impacts within this catchment;
- As part of the water supply assessment a geophysical survey was undertaken for Andrada, identifying eight (8) borehole locations that are proposed for further investigation. It was also recommended to try and locate existing boreholes within the identified regional target areas and determine if these could be used and if so, what their sustainable yields would be. If yields would be sufficient, these could provide an alternative groundwater supply source to the mine. Drawing large yields of groundwater for prolonged periods may have significant drawdown impacts for the regional aquifers.

- Where processes allow for it, water used in the plant should be recovered and reused as much as possible. The reticulation system must be maintained to reduce losses from the system;
- If possible water from the Uis wastewater treatment works could be recovered and used to supplement the water supply for the plant; and
- When possible Andrada could consider collecting and storing rainwater in non-operational pit areas which could provide a temporary supplement to the plant (Digby Wells, 2022).

For every alternative option there is a trade-off or an impact on another aspect of the Project. The detailed baseline environmental studies in the appendices, and summarised in the environmental baseline chapter, provide further information to the decision-making process.

4.18 REHABILITATION AND CLOSURE

The Proponent will commit to establishing a rehabilitation plan as part of the mine closure plan. A conceptual mine closure plan with costing is under development by UTMC in association with ECC and forms part of the EMP requirements and will be updated into the assessment phase.

The final mine closure plan currently under development is structured according to infrastructure placement on-site and what to do with them at specific time stamps. Each domain outlines the type of infrastructure present within it. The domain is then further broken down into possible uses under certain conditions for example, care and maintenance, premature closure, and post closure.

The different domains that have been developed are listed below:

- Waste rock dumps and the co-disposal facility
- Processing plant and salvage yard
- Surface roads and linear infrastructure
- Fuel depot
- Open pit and mining
- Workshops

UTMC undertook targeted consultations with relevant community stakeholders to establish the closure framework including appropriate cost schedules per domain. The development of this closure plan is a standalone exercise and not formally part of the current ESIA, however, some of the concerns raised overlapped with the ESIA scope and were subsequently addressed in this report. Some of these concerns were ground vibration complaints from blasting and dust nuisances from the same source as well as social issues related to economic empowerment. See Appendix B which contains the attendance registers of the workshops held in Uis between 9 and 11 August 2022.

5 ENVIRONMENTAL AND SOCIAL BASELINE

5.1 BASELINE DATA COLLECTION

Initial desktop baseline studies relevant to the Project formed part of the initial environmental assessments conducted for the mining licence on which the Project is situated. As part of this assessment, baseline conditions were studied in detail, with inputs from specialist studies commissioned as part of the environmental and social impact assessment process.

5.2 DESKTOP AND FIELD SURVEYS

Initial desktop baseline studies were completed between 2018 and 2021 for the Project. Additional desktop and field-based baseline studies were conducted between March and November 2021 and builds onto the dataset of site environmental monitoring data being collected since 2019.

This section sets out the biophysical and socioeconomic environments in which the Project is situated. It is an important part of the scoping component of the assessment, as it determines if there are any knowledge gaps that require additional information prior to the assessment phase being completed.

5.3 SPECIALIST STUDIES

The specialist studies as outlined in Table 11 were commissioned and completed to determine the current state of the baseline environments and conduct impact assessment studies.

Table 11 - Specialist and baseline studies conducted for the ESIA

Study area	Purpose	Specialists
Terrestrial ecology	Biodiversity and habitat. Identification of species of concern and sensitive areas. Impacts of mining construction and operations on habitats and biodiversity (if any).	Peter Cunningham
Hydrology	Water supply. Storm protection. Impact on heritage aspects. Clean and dirty water management systems.	Nurizon Consulting (Pty) Ltd
Groundwater	Assess the potential for contamination of aquifers from TSF & WRD. Provide a model to determine impacts of drawdown and plume mobility. Assess the sustainability of boreholes for water supply.	Digby Wells and ECC

Study area	Purpose	Specialists
Air quality	Provide emission standards and dust suppression requirements. Assess prevailing wind directions and possible effects of emissions on the process and/or personnel. Model potential air quality impacts.	Airshed
Noise and sense of place	Identification of possible receptors and assess levels of noise to which they may be exposed during construction and operations.	Airshed ECC
Traffic	The traffic impact assessment will study the potential traffic impacts and loading on routes associated with the mining activities. Assessing the capacity of infrastructure and safety aspects of the mine entrance. Assessing the need for an intersection upgrade at the mine entrance and providing a concept layout plan if necessary.	ITS Global
Heritage and culture	A heritage assessment is required, to comply with Namibian national legislature.	Dr John Kinahan
Visual and tourism	Assessing the potential visual impacts of a proposed Project on the receiving environment.	ECC
Social and economic	Includes the assessment of impacts on the social and economic landscape within the sphere of influence of the Project.	ECC
Geochemical sampling and analysis	The geochemical analysis of waste rock, tailings, and overburden will be undertaken to assess the mineralogical composition, acid mine drainage potential, and metal concentration of the leachate of waste rock and tailings.	ECC: Mine Waste and Management Consultants
Blast vibration impact	Assessing the impact of blasting on receptors in the area within the measured blast zone.	Blast Management and Consulting

5.4 Location

The proposed Project is located approximately 120 km inland from the Atlantic coastline. The site is within the settlement of Uis in the northern part of the Erongo Region and not within proximity to any other major town. Omaruru is situated east of Uis by approximately 122 km along the C36 gravel road. A small village called Okombahe is situated approximately 60 km southeast of Uis. The B2 main road can be accessed via the D1930 gravel road heading southeast from Uis toward Usakos for approximately 132 km.

5.5 LAND USE

The Project is situated in a predominantly subsistence agricultural region dominated by small stock farming land uses and to a lesser extent small-scale mining. Figure 25 outlines the proposed mining licence area map with surrounding land ownership status. Farming activities on surrounding properties will be able to continue relatively undisturbed by the proposed Project. The Project area is part of a communal reserve called the Okombahe Reserve and falls within the Tsiseb conservancy.

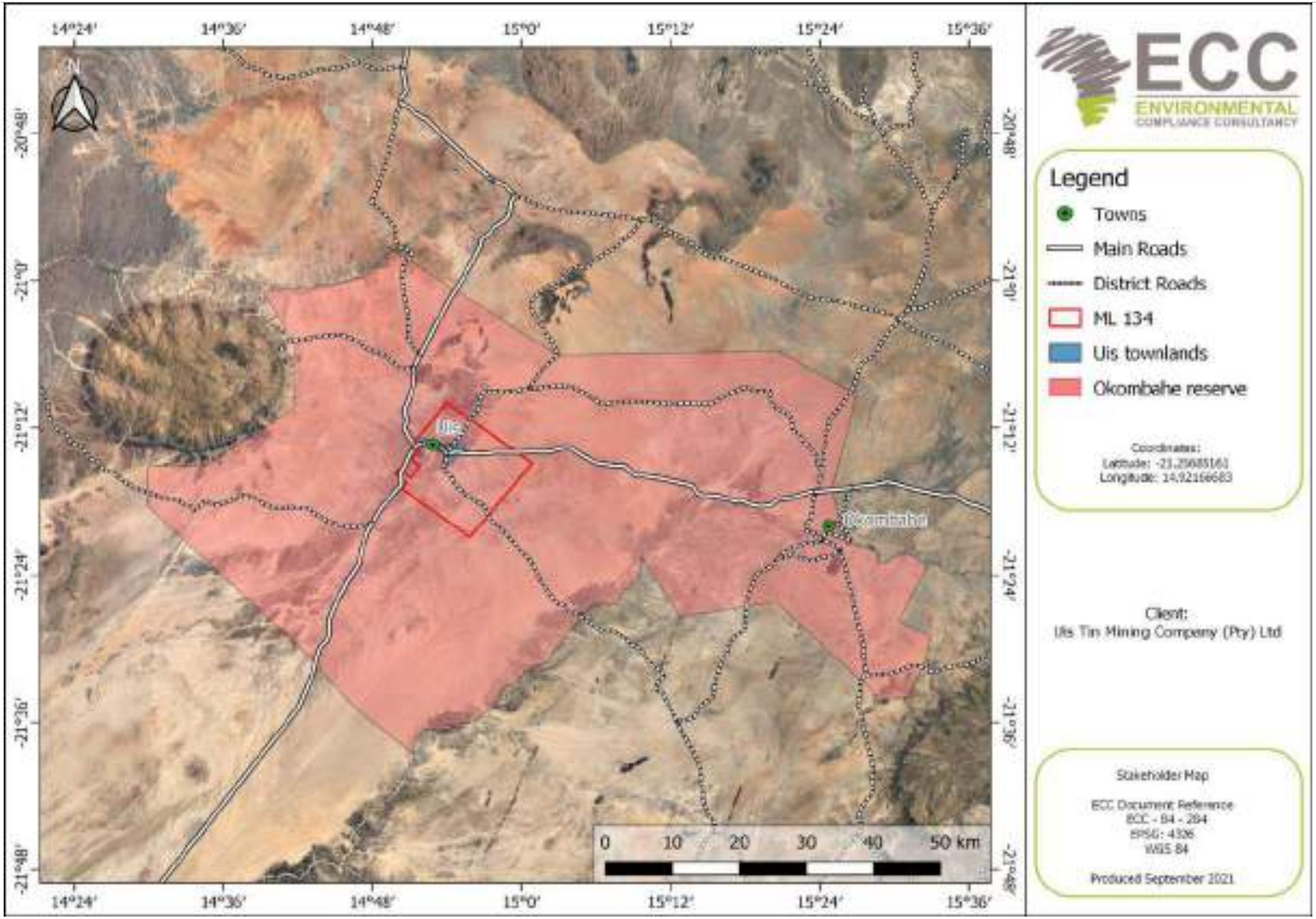

Figure 25 - A map showing the Project location within the Okombahe Reserve and in proximity to nearby villages.

5.6 GEOLOGICAL SETTING

The regional geology of the ML 134 area consists mainly of the Swakop Group and a very small section to the eastern side of the ML overlap Damara granites. The main rock types of this area are schists, dolomites, and granite. Granite hosts pegmatite dykes, within which are localised occurrences of tin and tantalum minerals, cassiterite and columbite-tantalite group. The Swakop Group is part of the Damara Supergroup and Gariep Complex (Bubenzer, 2002). The Uis Tin Mine focusses its mining activities on the cassiterite bearing pegmatites and produces a tin concentrate that also contains tantalum and lithium.

The different geological group formations associated with the ML are illustrated in Figure 26. Additional geology and mineralization details can be found above in Chapter 4.

5.7 TOPOGRAPHY

The topography of the ML is relatively flat with various rock outcrops and the elevation gradually decreases from the south-eastern side of the ML towards the north-western side (towards Uis), varying between 1050 m to just below 700 m above mean sea level. This ML is situated close to the Brandberg which is highly elevated at about 2475 m above mean sea level. This is illustrated in Figure 27.

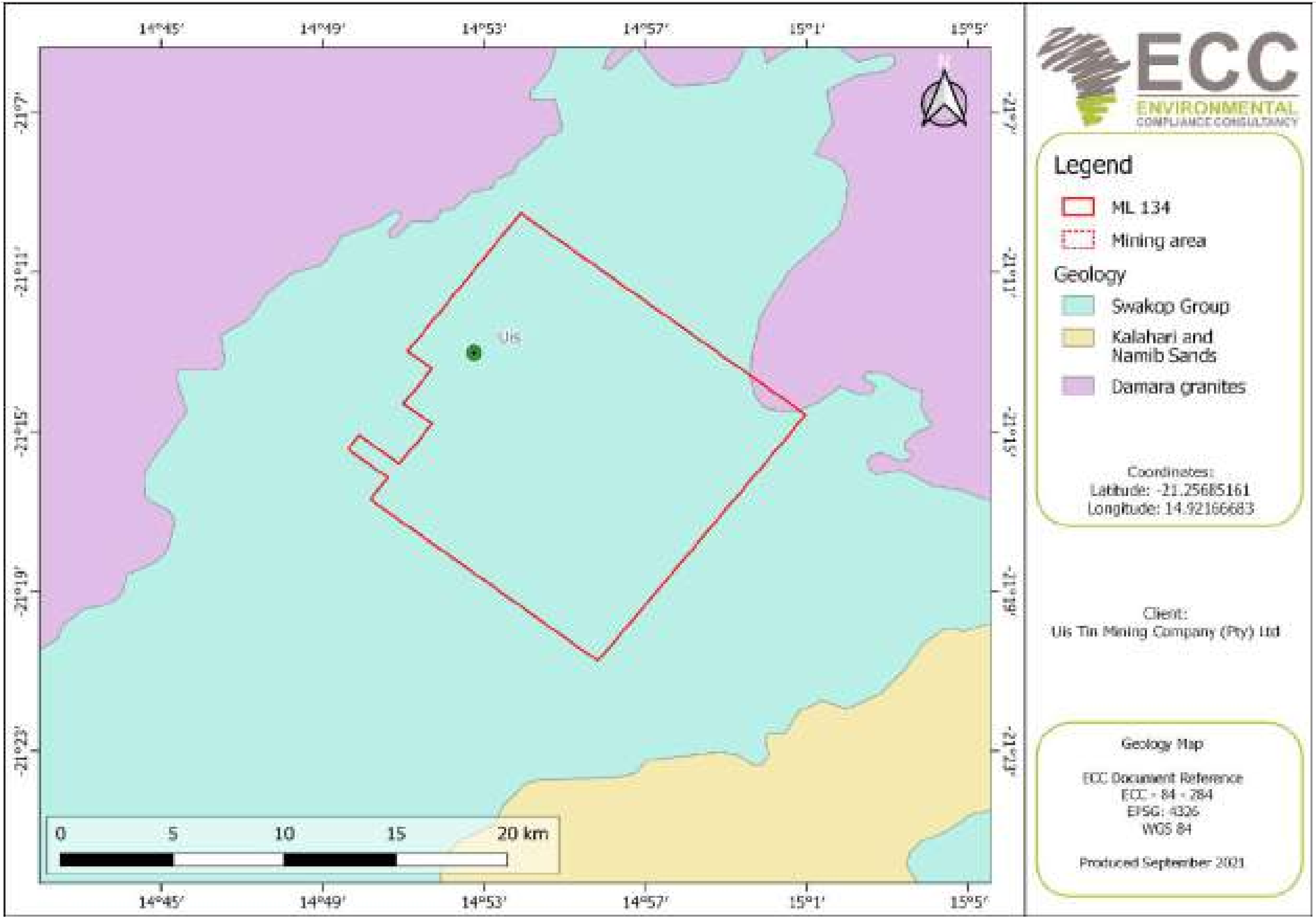

Figure 26 - A map showing the project location geological setting

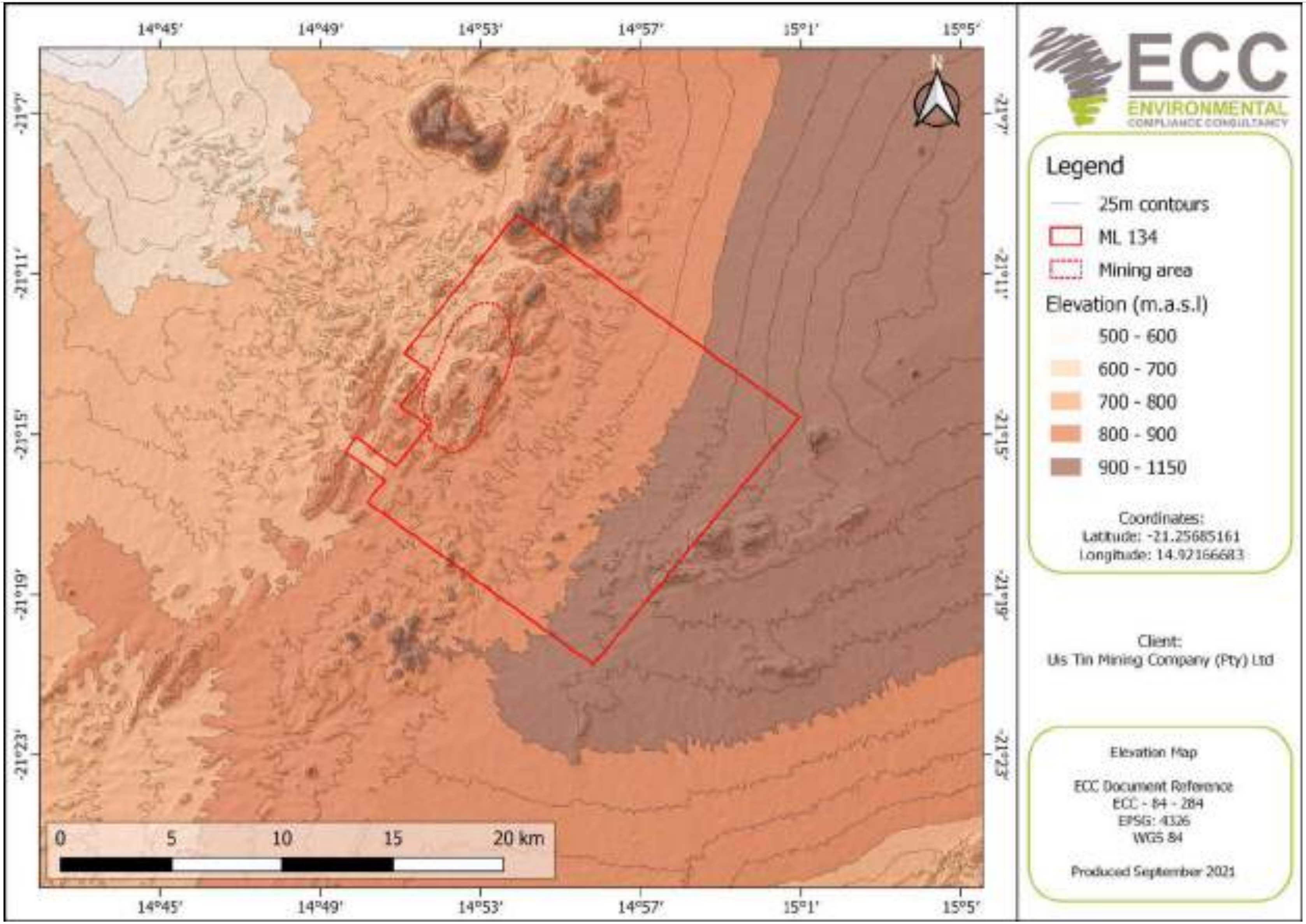

Figure 27 - Elevation map for ML 134.

5.8 SOILS

ML 134 is largely covered by rock outcrops and the area to the south-eastern side of the ML is covered by eutric regosols soil (Figure 28) (Bubenzer, 2002). Namibian soils vary a great deal, and variations occur on a broad scale but there is even a great deal of variability at a local level.

The first part of the soil name provides information on the properties of the soil, namely: eutric soils are fertile with high base saturation. The second name reflects the conditions and processes which have led to the formation of the soils (Mendelsohn et al., 2002). Regosols are medium to fine-textured soils of actively eroding landscapes. These soils are not as shallow as leptosols, but these soils never reach depths of more than 50 cm. This type of soil cannot provide vegetation with sufficient minerals or water (Mendelsohn et al., 2002).

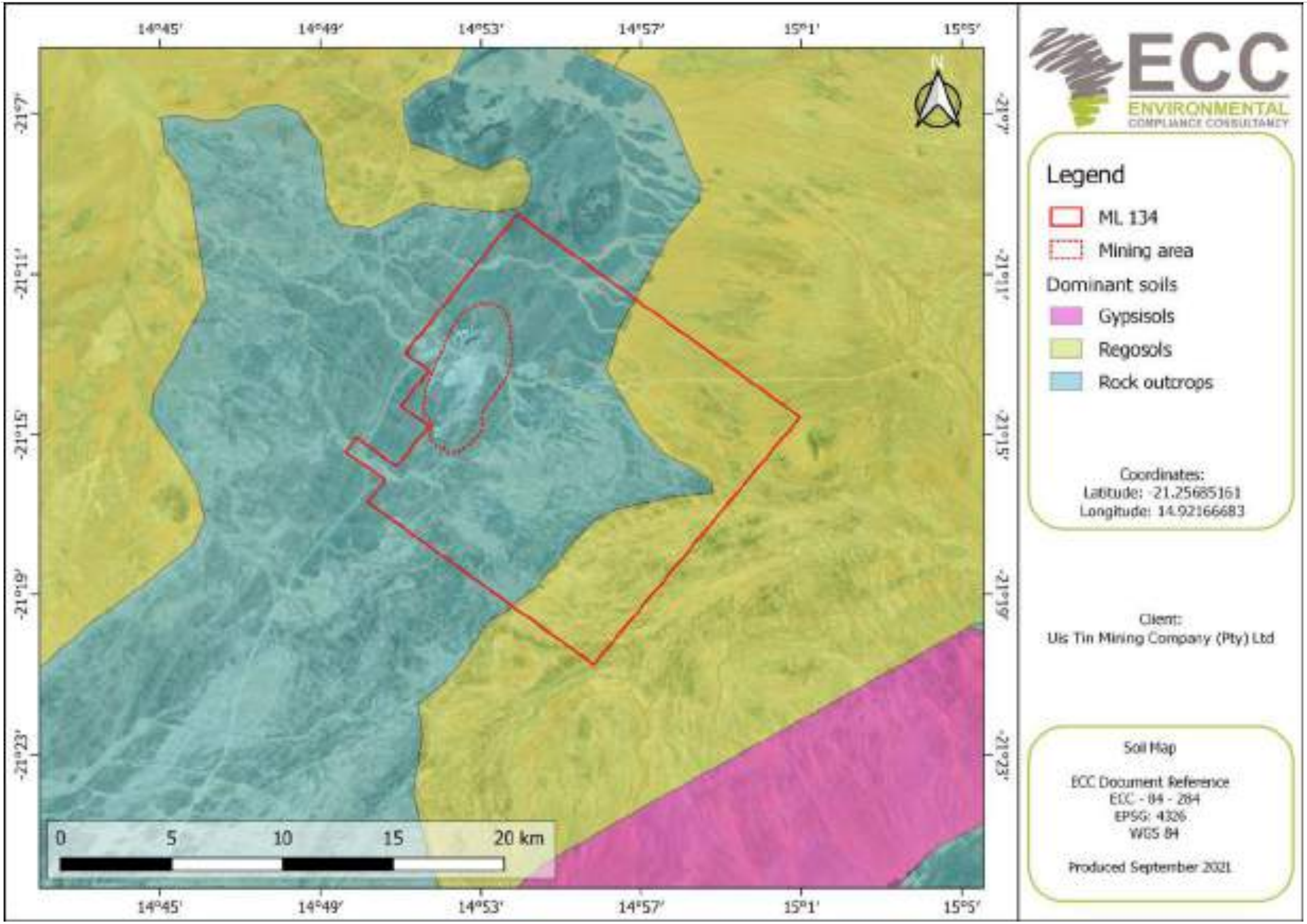

Figure 28 - Soil map of ML 134

5.9 HYDROLOGY AND GEOHYDROLOGY

ML 134 falls within the Ugab catchment area and over the Kunene South groundwater basin. In general, this region has little groundwater. Groundwater in the Project area (ML 134) is primarily associated with the interception of structures such as fractures (joints & faults) within subsurface hard rock (marble) bodies at various depths. On the ML there are a total of 11 boreholes of which four (4) are capped. Water is abstracted from seven production boreholes (Figure 29).

The Erongo Region in the central-western part of Namibia receives between 350 mm to less than 50 mm of rainfall per year. Most of the ML area is in the arid part of the Erongo Region with rainfall of less than 150 mm per year (Bubenzer, 2002). Evaporation is 2100 - 2240 mm per year. All river courses flow in a south-easterly direction through the ML (Figure 30).

5.9.1 LIMITATIONS OF THE HYDROGEOLOGICAL ASSESSMENT

Aquifer test study limitations:

- Although boreholes were scheduled to be switched off prior to aquifer testing the cluster area, observation borehole data may be influenced by abstraction in other cluster areas; and
- The community, landowners, and other business operations may have boreholes in the riverbed near the Uis and Southern wellfields. Abstraction from these third-party boreholes may influence the aquifer test results.

5.9.2 PHASE 1 STAGE II WATER DEMAND

With the increased production of tin concentrate to approximately 120 tonnes per month, the water requirement will also increase to 18.1 m3/hr.

5.9.3 RESULTS OF NUMERICAL MODELLING TO DETERMINE SAFE YIELD PARAMETERS

A provisional report (2019) was issued on the safe yield of water from the Uis aquifer. However, the results needed to be subjected to further bore field testing to deliver a final estimate (Van Wyk, 2019). That report represents the baseline conditions and was used as such by Digby Wells in designing its new pump testing regime, executed in early 2022. The current estimate based on the 2019 test pumping exercise conducted by Dawnmin Africa Investments (Pty) Ltd approximates to 340 000 m/a to 45 000 m/a over a 5-year cycle (2019 - 2023).

Andrada have two wellfields from which water can be drawn to supply the processing plant. The Uis wellfield is located in the Uis River, which runs through the northern part of mine area. There are seven boreholes located in this wellfield which are currently being used to supply water to the plant. The Uis wellfield boreholes are located within 2 km of each other and are expected to provide a combined average sustainable yield of 16.4 m3/hr. The Southern wellfield is located within a river channel approximately 6 km south of the mine and comprises three boreholes. A fourth low yielding borehole was drilled in this wellfield but has subsequently collapsed. The Southern wellfield is not currently operational. The three boreholes in the southern wellfield are located within 700 m of each other and are expected to provide a combined average sustainable yield of 2.3 m3/hr. These boreholes are in the process of being legalised with the Ministry of Agriculture, Water, and Land Reform. Once legalised, the abstraction volumes from these bores will be added to the overall project needs and will allow UTMC to submit a revised abstraction permit for an increased abstraction volume of 150 000 m3 per annum.

Initial groundwater levels measured in 2018 indicate that the water table typically occurs within the weathered zone of the fractured aquifer. The weathering profiles for the water supply boreholes indicate that the fractured aquifer is weathered to an average depth of 25 m and has a higher frequency of fractures between 20 – 50 m. Although the fracture frequency decreases after 50 m the fractures that are intersected can still be high yielding (i.e., borehole 8) (Digby Wells, 2022) (Appendix F).

Abstraction from the Uis wellfield boreholes since operations began in 2020 has drawn down the water levels in these boreholes by between 2.4 – 7.8 m. Groundwater levels within the Southern wellfield have decreased by an average of 1.4 m between 2018 and 2022, even though these boreholes are not operational (Digby Wells, 2022).

The results of the additional pump testing done on the Uis and southern wellfields by Digby Wells quantified a sustainable yield figure of 18.7m3/hr while the mine will require only 18.1 m3/hr over the LoM.

The sustainable yield for the available water supply boreholes were assessed as part of the hydrogeological assessment. simulates a cumulative sustainable abstraction yield of 18.7 m3 /hr for a 24-hour period for the ten (10) abstraction boreholes available to Andrada. This simulation would abstract a total annual volume of 163 812 m3/a from the aquifer. The sustainable yield per borehole (in m3) is provided in Table 12. These values were simulated as abstraction values for the water supply boreholes for an 18-year Life of Mine period. See Section 4.17 outlining potential additional water source figures to augment the current water supply regime for the mine.

Table 12 - Sustainable yield per borehole

Borehole	Average sustainable yield (units)	Borehole	Average sustainable yield (units)
BH1	0.4	BH8	8.5
BH2	0.2	BH9	0.9
BH3	0.3	BH10	4.0
BH4	1.0	BH11	1.4
BH6	1.0	BH12	1.0
Total Yield		18.7	

The resulting drawdown cone will extend ~6.5 km from the mine and will have a drawdown of ~4.5 m in the area of the wellfield. The numerical model results indicate the abstractions will be sustainable, however, they will stress the aquifer due to the low recharge potential of the area. Hence, the need for alternative water supply sources later during operations. The Proponent is considering the establishment of a desalination plant

Based on the rainfall data available for the area (from 1979 to date), there are regular peak rainfall events that assist with recharging the aquifer, as was observed during the first few months of 2022 after a major rainfall event. Groundwater level observations on site showed an increase in groundwater levels in the water supply boreholes of between 0.8 m – 8.3 m, in response to the site receiving ~90 mm of rainfall (Digby Wells, 2022).

5.9.4 GROUNDWATER QUALITY

The project area is characterised by fractured igneous and metamorphic rock aquifers which are overlain by shallow alluvial aquifers in river channels. The aquifers receive low recharge (less than 0.7% MAP or 0.61 mm/a), and the hydrochemistry is, therefore, representative of groundwater with a long residence time or slow-moving groundwater allowing rock interaction processes to occur over long periods which affords groundwater more time to mineralise subsurface (Digby Wells, 2022). Therefore, groundwater hydrochemistry is characterised by high concentrations of sodium chloride and sulphate. Interpretation done by Dawnmin Africa Investments is based on a tri-linear diagram (piper plot) and classifies the Uis groundwater as “sodium chloride” (brackish) type water (Van Wyk, 2019).

The isotope samples were collected to trace links between the water located in the K5 pit with surrounding groundwater locations. The five water samples represent groundwater (BH8, BH10, BH12), pit water (K5) and rainwater (Rain 2). Two samples were collected from each site, 1 x 1 l sample for the tritium analysis and 1 x 40 ml sample for the stable hydrogen (δ2H) and oxygen (δ18O) analysis. No additives or preservatives were added to the samples. The samples were submitted to Ithemba Laboratories in South Africa for Analysis. Subsequently during the recent Digby Wells hydrogeological assessment water quality samples were taken from the water supply boreholes between December 2021 and January 2022. These are compared with 2018 water quality data collected during van Wyk’s drilling and aquifer testing project. pH, electrical conductivity, and total dissolved solids were used to describe the general condition of the groundwater. The trends for pH and electrical conductivity and total dissolved solids indicate that the results for the water supply boreholes are of a similar range to the boreholes tested in 2018 (Digby Wells, 2022).

Stable isotopes of oxygen (18O) and hydrogen (2H) can be used as environmental tracers. The composition of stable isotopes in natural waters can change based on physical, chemical, and biological processes that occur within the hydrological cycle as a result of isotope fractionation.

Tritium is a radioactive isotope of hydrogen which has been applied in age determinations of groundwater and trace amounts of this isotope have been picked up in the water samples taken from the northern pit (K5).

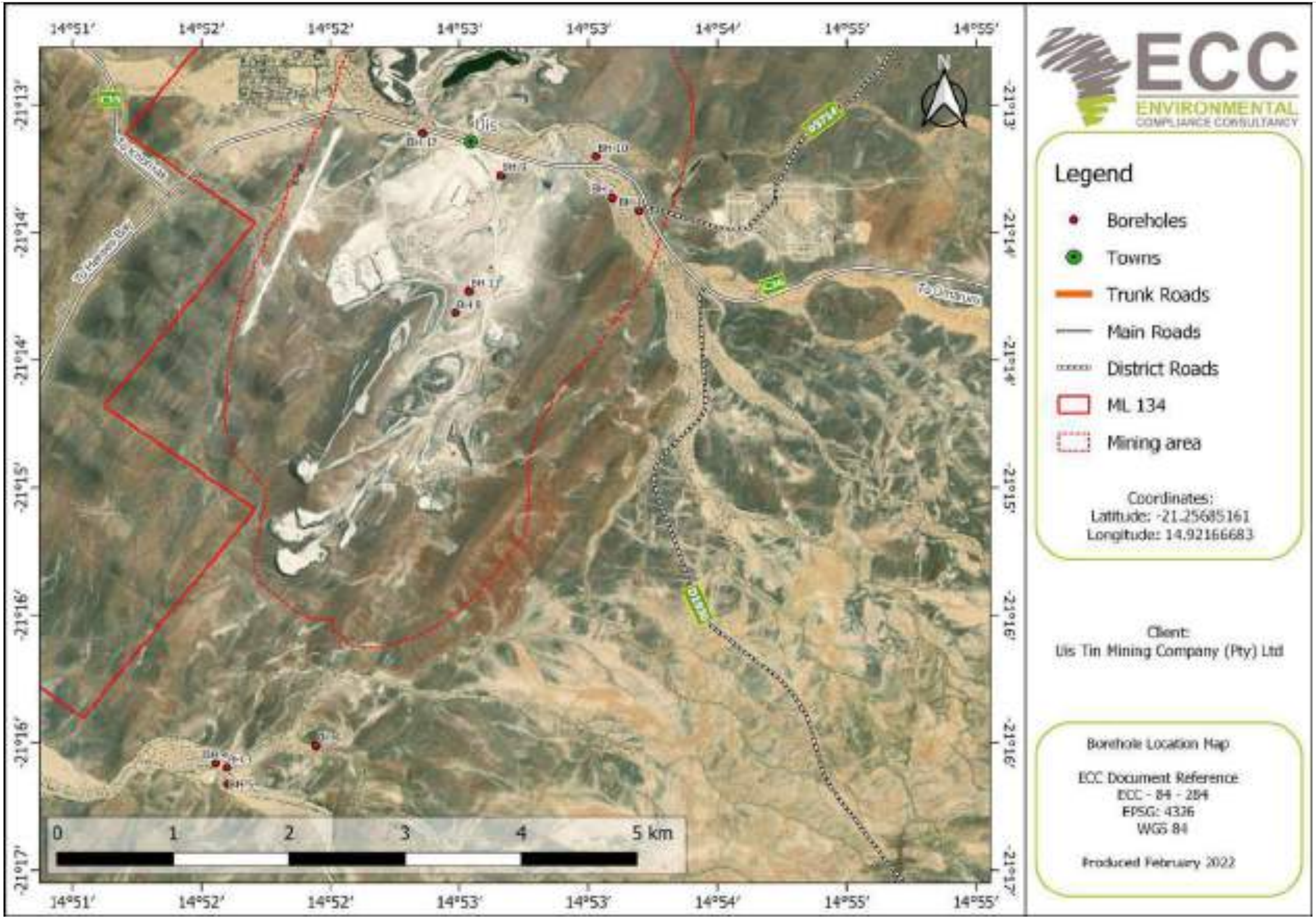

Figure 29 - Borehole locations

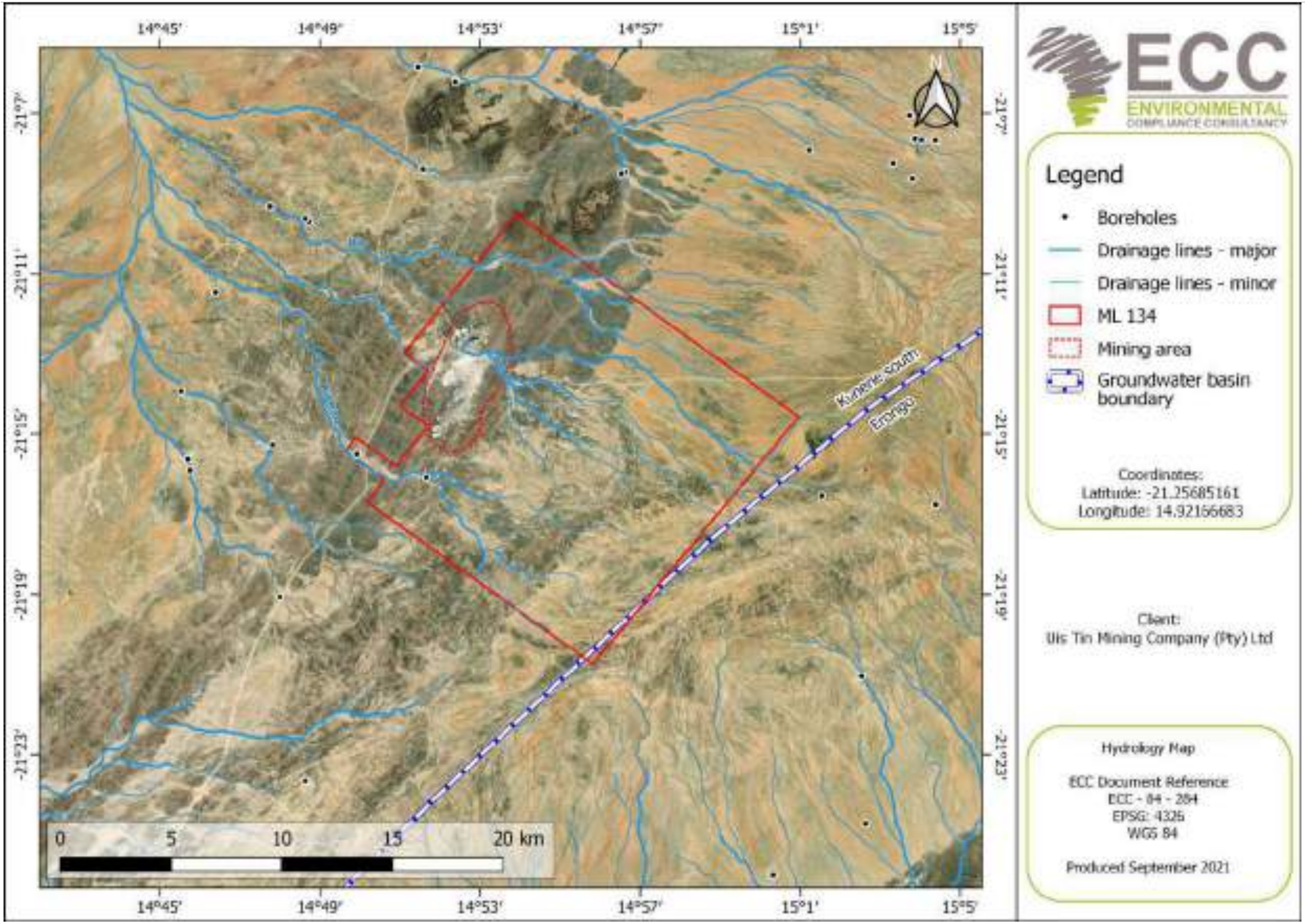

Figure 30 - Hydrology map of ML 134

5.9.5 BOREHOLE RECOVERY LIMITS

The numerical model simulations indicate that when the end of mine life is reached, and the abstraction requirements cease, the drawdown cone will extend ~6.5 km from the mine with a drawdown of ~4.5 m in the wellfield area. The drawdown contours were used to calculate the area for the dewatered extent and the dewatered volume using ArcGIS version 10.8.1. This was used in conjunction with the porosity factor (numerical model) and recharge to calculate that the estimated water level recovery period would be 58 years post closure (Digby Wells, 2022). See Table 13 extracted from the Digby Wells hydrogeological assessment report.

Table 13 - Analytical calculation inputs

Input	Value	Unit
Area of influence	65 075 284	m2
Dewatered volume	228 472 561	m3
Porosity3	0.01	%
Volume of pore space to be filled	2 284 726	m3
Recharge	0.61	Mm/a
Recharge over area of influence	39 696	m3/a
Time to fill area of influence	58	years

5.10 BIODIVERSITY

Environment and Wildlife Consulting (2021) undertook a specialist assessment study of the vertebrate fauna and flora on ML 134. The dry season assessment report was completed late 2021, and the wet season assessment conducted in early 2022 after initial rains have fallen in Uis. The baseline studies for both seasons is the basis upon which the full assessment will be carried out, notwithstanding the relevant information gathered and recorded in from publicly available information sources. An assessment of the potential impacts was carried out using the impact assessment methodology used by ECC.

5.11 VEGETATION

Vegetation type and structure in Namibia is strongly influenced by rainfall. The plant diversity and tallest trees are most lush in the north-eastern parts of the country and contrast sparser and shorter to the west and south of the country. This gradient is not simple as other factors such as soil types and landscape also influence the vegetation. The dominant vegetation structure of ML 134 is sparse shrubland and grasses (Figure 31) (Bubenzer, 2002 & Mendelsohn et al., 2002).

The area has unique vegetation and wildlife species including reptiles and avifauna, many of which are endemic to the Namib Desert. ML 134 lies within the Nama-Karoo Biome and central-western escarpment type, which tends to have sparse shrubs and grassland occupying the gravel plains. The grass cover is sparse but dominates the little vegetation that grows on the gravel plains. The plant diversity of the areas is moderate (between 150 to 300 species) and the endemism is moderate to high (between 6 and 35 endemic species), with the higher number of species estimated to the northwestern side of the mine licence, near the mine site (Bubenzer, 2002 & Mendelsohn et al., 2002).

A list of plant species that could be found within and surrounding ML134 has been provided by the National Botanical Research Institute (NBRI) and can be seen in Appendix G. As in the NBRI tables, there is a low to moderate plant diversity and high endemism within these areas; of all the species found within these areas, 11 species are near-endemic, 20 species are endemic, and five (5) species are protected.

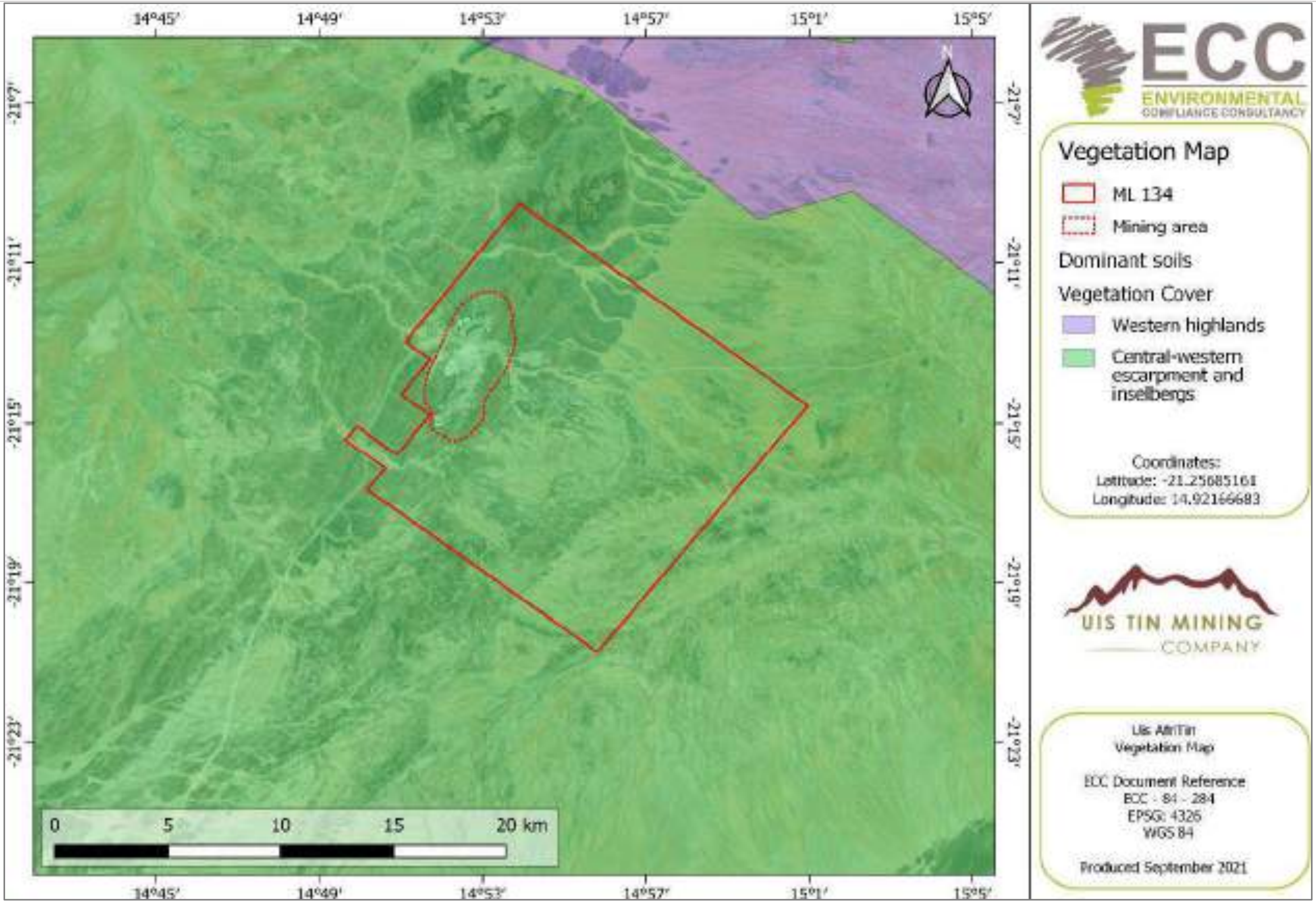

Figure 31 - Vegetation map of ML 134

5.12 FAUNA SPECIES

The area within and surrounding the ML has 111 to 140 bird species (moderate to high endemism with six to seven species), which is of medium diversity in comparison to the rest of Namibia, which has a total of up to 658 recorded bird species. The number of observed lizard species for this area is between 32 to more than 35 different species (high endemism with 12 to 14 species) and the mammal diversity of this area has been recorded to be from 61 to 75 species (high endemism with 7 to 8 species). The large carnivore diversity is approximately four (4) species for this area, thus the overall terrestrial diversity for this area is low in comparison with the rest of the country, but this area has an overall high species endemism (Bubenzer, 2002 & Mendelsohn et al., 2002).

Furthermore, the rodent diversity ranges between 16 to 23 species as recorded for this area and the different snakes recorded are between 20 to 29 different species (Bubenzer, 2002 & Mendelsohn et al., 2002).

The diversity of mammals and reptiles in the area is generally low and low with respect to the rest of Namibia, but this area is represented by various important species that need to be protected, some of which are critically endangered, such as the White-backed Vulture (Bubenzer, 2002, IUCN, 2021 & Mendelsohn et al., 2002). Although this area does not have the highest diversity of species in Namibia it clearly has a unique and sensitive ecosystem with high endemism and some High Conservation Value (HCVs) species (Bubenzer, 2002, IUCN, 2021 & Mendelsohn et al., 2002).

This part of the Erongo Region is relatively untouched, as most people that live within the area are confined to settlements, lodges/camps or larger towns like Uis. Within this area (Brandberg and Ugab River), there are also desert-adapted Elephants, which is not a distinct species, they are African bush elephants (Loxodonta africana), that are also specifically adapted to these harsh desert environments. There are approximately 62 desert adapted elephants left within the southern Kunene and northern Erongo regions; they mainly move within the ephemeral rivers, where they get water, food, and shelter under larger trees. A 32% decrease was seen since 2016 among the desert-adapted elephants, residents to the Ugab River, which was partly due to anthropogenic and natural reasons (major drought) (Elephant-Human Relations Aid, 2020).

In the Ugab and Huab rivers between 2014 and 2018, nine (9) out of 14 newborn elephant calves died, the exact causes were unknown, but human-caused stress factors and harsh environmental conditions may have contributed to this. These elephants are keystone species that play an essential role within these local desert ecosystems as they usually dig for water, making these resources available to other animals, as they break off large branches from trees, that assists smaller animals to also get access to green fodder in the drier seasons. Their deep tracks in the mud during the short rainy season provide an ideal environment for seedlings, which is essential for vegetation growth. Thus, these desert-adapted ecosystem engineers form an essential part of the balance within the desert ecosystem. The African Bush Elephant is an endangered species which contributes to the annual revenue of Namibia through tourism (Elephant-Human Relations Aid, 2020).

5.13 BUILT ENVIRONMENT AND INFRASTRUCTURE

5.13.1 INFRASTRUCTURE AND BULK SERVICES

The tarred C36 road transecting the town carries significant traffic volumes between Windhoek and Henties Bay and is considered an important tourism route to the Brandberg massif and surrounding attractions. This is also the primary access route to the site.

The D1930 and D3714 gravel roads converge on the town from the east and northeast and connect to the C36 tarred road, which is the main road east to Omaruru, and to Henties Bay the route to which is shared as the C36 and M76. The D1930 is used to connect to the B2 highway that runs between Swakopmund and Windhoek. The D3714 branches off onto the D3715 and connects to Omatjete in the Kunene Region further northeast.

NamWater currently has an unused wellfield in the upper Uis River, with an associated reservoir and pipeline laid towards Uis.

Bulk water to Uis is pumped by NamWater from the Nei-Neis Water Supply Scheme south of Uis to a reservoir within Uis. This is used to supply potable water to the residents of Uis.

The town is supplied by a 66kV overhead power line by ErongoRED. The power supply for the Uis Tin Mine is derived from the grid consisting of a 66kv power line (approximately 1 km long) and a substation with associated infrastructure (Figure 32).

The power line and infrastructure are located within the Accessory Works Permit area, permitted by the Ministry of Mines and Energy (16 October 2018) in terms of Section 90 (3) of the Minerals Act 33, 1992 and has a valid environmental clearance certificate.

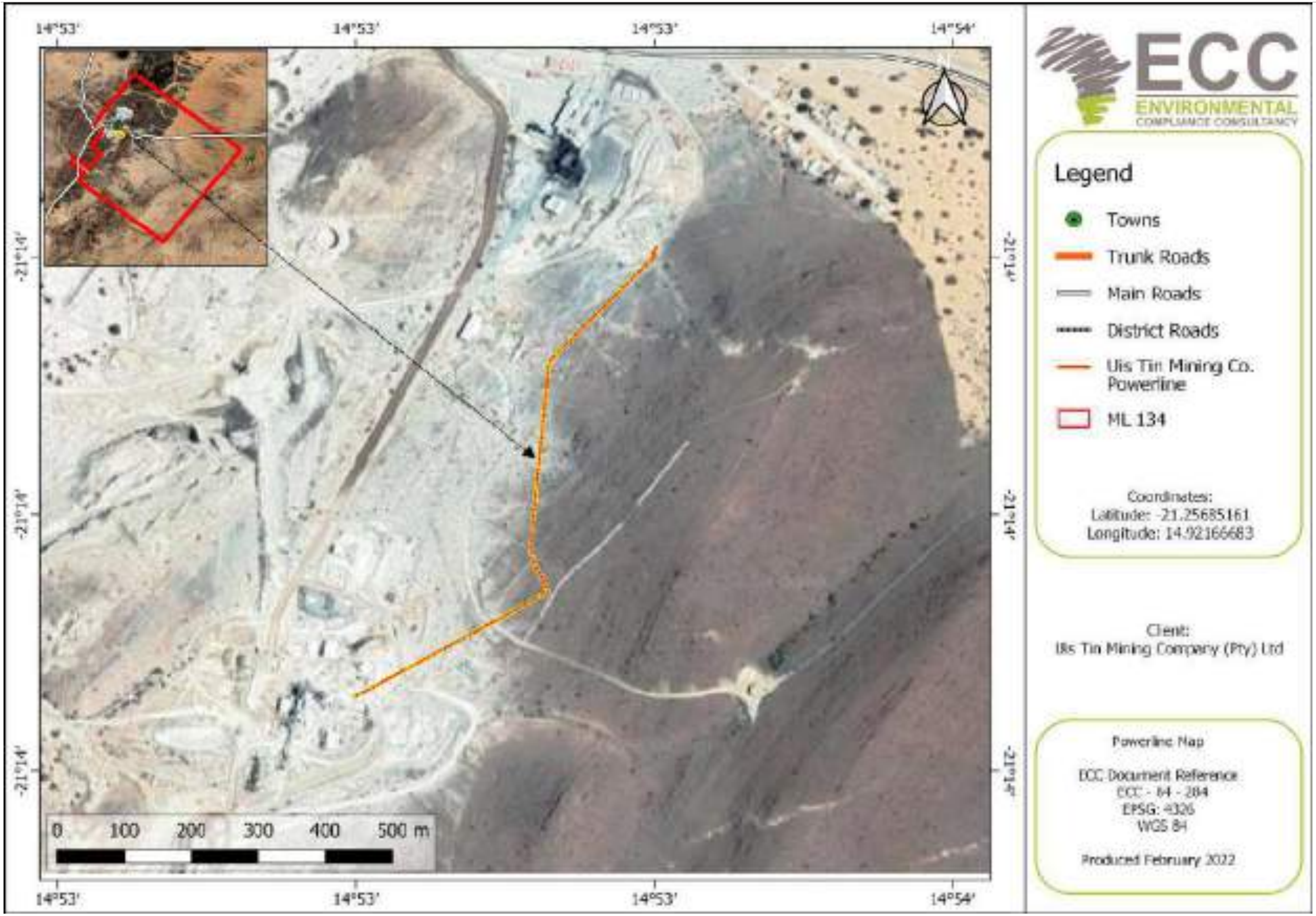

Figure 32 - A map showing the power line infrastructure

5.14 TRAFFIC AND TRANSPORT

Innovative Transport Solutions (ITS Global) was commissioned by ECC to assess the road traffic baseline of the project area (Figure 33). The major existing roadways in proximity to the Project area include:

- The C36 Road (T0203) (blue line) – Class 2 major arterial, with a surfaced lane (approx. 3.5 meters wide) per direction. Gravel shoulders and a speed limit 80 km/h within Uis, and
- The D1930 and D3714 Roads (red line) – Class 4 distributor, with a gravel lane per direction.

Figure 33 - Class routes assessed for the study indicated in blue and red lines

These routes were assessed for capacity to handle road traffic from the mine fleet and the public during two timestamps, 06h00 to 08h00 in the morning and 16h00 and 18h00 in the evening. Parameters that were assessed included shoulder sight distance at the access intersection to the mine, speed limits and road conditions and the expected number of traffic contributed by the mine on the roads being assessed.

5.14.1 METHODOLOGY

The C36 mine entrance intersection is a "T" intersection, with free flow along the C36 and a stop control on the mine exit, and a single lane on each approach. See Figure 34 showing the existing lane configuration and traffic control.

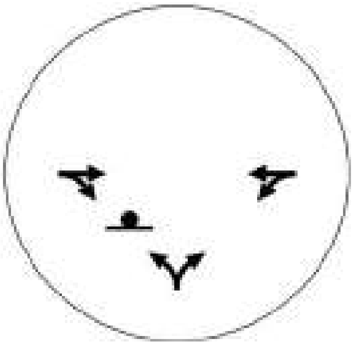

Figure 34 - Existing site geometry (ITS global, 2021)

The C36 mine access intersection was surveyed / counted on 18 November 2021. The 2021 existing traffic conditions are based on the current intersection geometry / control, as well as the existing traffic volumes. Based on the existing traffic capacity analysis results, this intersection currently operates acceptably, from a capacity analyses point of view, with the following results:

- Level of Service (LOS) A during all peak periods,
- Delays less than 10 seconds on average during peak periods, and
- Volume to Capacity (v/c) ratio is less than 5 percent during peak periods.

The volume to capacity ratio is an indication of whether an intersection is operating under-or over-capacity. With a very low v/c ratio of less than 5 percent, it means that there is more than 95 percent spare intersection capacity currently available.

See Figure 35 showing the existing traffic conditions for the weekday morning, midday and evening peak hours respectively.

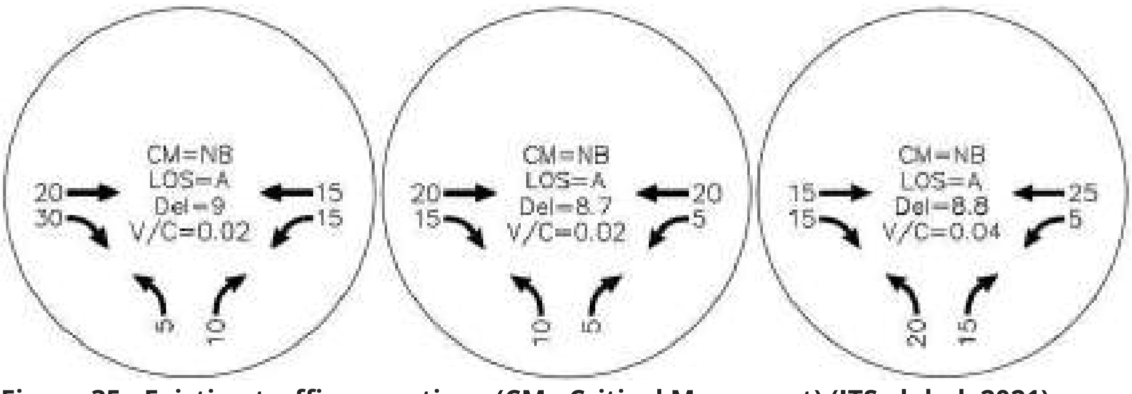

Figure 35 - Existing traffic operations (CM =Critical Movement) (ITS global, 2021)

5.14.1.1 Scenarios analysed

Scenario 1: 2021 Existing Traffic conditions. Based on existing geometry and traffic volumes. Based on the existing capacity analysis results, the study intersection operates acceptably. Hence, no upgrades are required from a capacity analysis point of view.

Scenario 2: 2026 Background Traffic conditions (Based on Scenario 1 traffic volumes, escalated with a 3% growth rate per year.) Based on the background traffic capacity analysis results, the study intersection would continue to operate acceptably. Hence, no upgrades are required from a capacity analysis point of view.

Scenario 3: 2026 Total Traffic conditions (Based on Scenario 2 traffic volumes, PLUS the additional trips for the proposed mine expansion). Based on the Total Traffic capacity analyses results, the study intersection would continue to operate acceptably. Hence, no upgrades are required from a capacity analysis point of view.

Intersection analyses were done with Traffix version 8.0 Software, which is based on the Highway Capacity Manual (HCM).

Surrounding Roads: The condition of the C36 roadway, near the development, is in relatively poor condition with various spots of cracking and failure.

Existing Operations: The C36 / mine access intersection currently operates acceptably, from a capacity analysis point of view.

Heavy Vehicles: Approximately 4 trucks enter/leave the site per day. This is about 30 percent of trucks per day from the total traffic at the C36 / mine access intersection.

Public Transport: Approximately 17 buses enter/leave the site per day. This is about 55 percent of buses per day from the total traffic at the C36 / mine access intersection.

Pedestrians: A minimum of 250 meters shoulder sight distance is available, and pedestrians can easily cross the roadway as there are less than 100 vehicles in an hour traveling along the C36. Pedestrians can walk along the C36 roadway on the wide gravel shoulders which are approximately 4 meters wide.

5.15 Socioeconomic baseline

Namibia’s GDP is recorded at 14 billion US Dollars as of 2019 (Plecher, 2020). The development of the services sector, which directly includes tourism-related products and services have created a significant positive impact on domestic and national economic growth levels; employment; and local and regional development. Examples of this are the continued development of small and medium-sized tourism-based accommodation developments throughout the country as well as large-scale tourism developments, including eco-tourism with a strong focus on wildlife marketing.

ML 134 is located within the Erongo Region, named after Mount Erongo, a well-known landmark in Namibia. Erongo contains the municipalities of Walvis Bay, Swakopmund, Henties Bay and Omaruru, as well as the towns Arandis, Karibib and Usakos. All of the main centres within this region are connected by tarred roads, the capital is Swakopmund. The area surrounding the town Uis and ML 134 are less developed than some of the larger towns in the Erongo Region, as mentioned above.

The ML overlaps the communal conservancy Tsiseb. A communal conservancy represents a conservation area that is managed by a local community that aims to manage the natural resources within their conservancy in a sustainable way to generate returns and other benefits (MET/NACSO, 2018). The local residents are mainly employed by lodges, rest camps, and livestock or game farms. Tourism and consumptive wildlife use is the main benefit contributor to these local communities, as well as income generated from plant products and local crafts (MET/NACSO, 2018).

According to MET/NACSO (2018), "Wildlife is central in generating returns for conservancies", thus it is essential to ensure that the ecosystem and biodiversity are healthy within these communal conservancies to ensure a bright future for both wildlife and Namibia's local communities. Any major environmental or ecological impacts within these areas could compromise the success and future of the Community Based Natural Resource Management (CBNRM) program, which mainly depends on healthy wildlife populations for tourism and consumptive wildlife use.

Once the new bulk sampling, sorting, and testing facility is ready to be operationalised, between 10-15 additional operators will be employed from the pool of local labourers in Uis where feasible. The operators will be trained as required to ensure safe operational practices during the ramp-up phase of the project.

The EPC contractor for the facility's construction is a specialised role and will be performed by a suitable company that UTMC will appoint.

With the expected overall production output from 80 to 120 tph of ore from the mine it is expected that internal revenue generation will also increase in the form of payments received for mineral products sold worldwide. The company in turn will continue to pay taxes, levies, and royalties payments to the government. The mine's capital expenditure and operational expenditure will also be channelled into the local, regional, and national spheres, therefore, contributing directly and indirectly to the micro and macro-economies.

It is notable that the tin price in USD has tripled in the last 15 years which is evidence of a growing market for the resource. Coupled with the fairly stable exchange value of the NAD to USD the overall revenue in NAD may increase.

5.16 Governance

Namibia was established in 1990 and is led by a democratically elected and stable government. The country ranked fifth out of 54 African countries in the Ibrahim Index of African Governance in 2015 for indicators that include: the quality of governance and the government's ability to support human development, sustainable economic opportunity, rule of law, and human rights (National Planning Commission, 2017).

As a result of sound governance and stable macroeconomic management, Namibia has experienced rapid socioeconomic development. Namibia has achieved the level of 'medium human development' and ranks 125th on the Human Development Index out of 188 countries (National Planning Commission, 2017).

Namibia is divided into 14 regions and subdivided into 121 constituencies. The Erongo Region is divided into seven constituencies. The proposed Project is in the Karibib constituency of the Erongo Region. The Erongo Regional Council is responsible for the planning and development of the region in a sustainable manner for the benefit of its inhabitants by establishing, managing, and controlling settlement areas and focusing on core services. The council is accountable for an area of 63 586 km2, which is about 7.7% of the total area of Namibia (Erongo Regional Council, 2017).

5.17 Demographic profile

Namibia is one of the least densely populated countries in the world (2.8 persons per km2). Vast areas of Namibia are without people, in contrast to areas of dense concentrations, such as the central-north and along the Kavango River. Windhoek, the capital, is not only the main urban area with the largest population, but the concentration of private and public head offices attracts Namibians from all parts of the country in search for a better life.

The national population growth rate is estimated at less than two percent, which is lower than that of most African countries. Namibia's population is young – although 57% falls into the age group 15 to 59, 37% of the total population is younger than 15 years old (Namibia Statistics Agency, 2017). Since 2005, there has been a steady improvement in life expectancy, which is currently estimated at 65 years. In 2018, it was estimated that 50% of all Namibians are urbanised, i.e. living in an urban settlement (retrieved from www.worldpopulationreview.com). The last national census was conducted in 2011, and counted 2.1 million Namibians (Namibia Statistics Agency, 2011). An inter-censal demographic survey was conducted in 2016 and estimated the total population at 2.3 million (Namibia Statistics Agency, 2017).

It is predicted that urbanisation will continue, with an increase and move from 43% of the population living in urban areas in 2011, to 67% in 2041. The populations of the Khomas and Erongo regions are projected to increase the most, with over a third of Namibia's population expected to live in these two regions (Namibia Statistics Agency, 2011).

In the 2011 census, the population of the Erongo Region was 150 809, with a growth rate of 28.6% since 2001. The population of Namibia has been growing steadily; the population growth rate between 2001 and 2011 (the two censuses) was 1.4%, with urban areas growing quicker than rural areas. The highest growth rate in Namibia was recorded in the Erongo region (3.4%). This was mainly influenced by in-migration; more than 40% of residents in these regions were born elsewhere. Situated in the central Namib Desert, Swakopmund is the capital of Erongo and the fourth-largest town in Namibia with 44 725 inhabitants (Namibia Statistics Agency, 2011). In 2010, Uis had a population of approximately 3 600 inhabitants.

The potential impacts associated with the introduction of the Project to the area will be assessed as part of the ESIA, taking the baseline conditions and the Project into consideration during the assessment, to determine the magnitude of change from the baseline, and the potential impacts associated.

5.18 HEALTH

Since independence in 1990, the health status of Namibia has increased steadily, with a remarkable improvement in access to primary health facilities and medical infrastructure. In 2015, the World Health Organization (WHO) recommended strategic priorities for the health system in Namibia, which entailed improved governance, an improved health information system, emergency preparedness, risk reduction and response, preventative healthcare, and the combating of HIV/AIDS and TB (WHO, 2016).

According to the MoHSS health facility census (MoHSS, 2009), the Erongo Region has a record of approximately 150 facilities which include individual private health care practices, group private health care practices, primary health care clinics and workplace clinics. Erongo has a high life expectancy which, as of 2011, was 63 years.

As with elsewhere in Namibia, HIV/AIDS remains a major reason for low life expectancy and is one of the leading causes of death in the region. HIV/AIDS remains the leading cause of death and premature mortality for all ages, killing up to half of all males and females aged 40 to 44 years in 2013 (IHME, 2016).

Tuberculosis (TB) is a leading killer of people infected by HIV/AIDS, and Namibia had a high burden in 2018 – 35% of people with TB were infected with HIV. The country is included among the top 30 high-burden TB countries in the world, with an estimated incidence rate of 423 per 100 000 people, and 60 fatalities per 100,000 people in 2018 (retrieved from www.mhss.gov.na).

As at the beginning of 2020, the coronavirus (COVID-19) caused illness in humans at a pandemic scale, and has resulted in an increasing number of deaths worldwide. The viral outbreak has adversely affected various socioeconomic activities globally, and with reports of a continually increasing number of people testing positive, it is anticipated that this may have significant impacts on the operations of various economic sectors in Namibia too. The disease caused many countries to enter a state of emergency, which included various levels of lockdown restrictions that had dire economic consequences. In addition, these measures have had a detrimental effect on tourism, and Namibia is, in both cases, no exception.

Furthermore, COVID-19 has also resulted in a loss of learning and socialising opportunities for children in Namibia and there was a lack of access to school feeding programs and parents had to provide or find alternative care for children. There has also been a six percent increase in health worker appointments across Namibia as a result of the pandemic (United Nations Namibia 2020).

5.19 Employment

The Erongo Region is one of the most affluent regions in Namibia, with the second highest per capita income in Namibia at N$ 16 819 per annum (Environ Dynamics, 2010). In Walvis Bay, most employment is through the harbour, fishing industry, and the processing of sea salt (Walvis Bay Municipality, 2008).

The labour force participation rate is the proportion of the economically active population, given as a percentage of the working age portion of the population (i.e. older than 15 years of age). The rate of labour force participation for the Erongo Region was 80.9% compared to the average of 71.2% for Namibia in 2018 (Namibian Statistics Agency, 2019).

In 2018, 53.4% of all working Namibians were employed in the private sector, and 21.5% by the state. State-owned enterprises employ a further 7.6% and private individuals 16.6%. Agriculture (combined with forestry and fishing) is the economic sector with the most employees – 23% of all employed persons in Namibia work in this sector. Wages and salaries represented the main income source of 47.4% of households in Namibia (Namibian Statistics Agency, 2019).

Low education levels affect employability and prevent many households from earning a decent income. Of all employed people in Namibia, 63.5% do not have more than a junior secondary level qualification (Grade 10 and lower), and 11.8% of all employed people have no formal education. In total, 29.1% of all employed people fall into the category of “elementary occupation”, and 15.2% into the category of “skilled agriculture”.

Overall, the rate of unemployment is estimated at 33.4 % for Namibia. The unemployment rate in rural and urban areas is almost the same: 33.4% in urban areas and 33.5% in rural areas. The highest unemployment rates are found amongst persons with education levels lower than junior secondary. The unemployment rate of persons with no formal education is 28.6%, with primary education at 34.6%, and junior secondary education at 32.7% (Namibian Statistics Agency, 2019).

According to the Namibian Chamber of Mines 2020 annual review, the mining industry employs over 9,000 people directly in the industry – 800 temporary employees and over 6 500 contractors. The Namibian mining industry spent almost two million Namibian dollars on skills expenditure, including operating mines, and exploration and development companies such as UTMC.

5.20 Crime

Namibia's crime rate has been on the decline, in general and in the Erongo Region, since 2011.

Namibia has a large market for ivory, rhino horn and pangolins. Since 2016 it has lost an average of 50 rhinos per year to poaching. Although it draws less attention than other wildlife species, the poaching of hippos is prevalent in Namibia. Illicit fauna products are often hidden among illegal stacks of timber on smuggling missions. Criminal syndicates appear to be increasingly involved in poaching and wildlife trafficking. While most poachers in the country are Namibians, foreign citizens from countries such as Zimbabwe and Angola are also involved. Illegal fishing also takes place in Namibian waters, primarily by foreign vessels (Global Organised Crime Index).

5.21 Economic and business activities

Key economic activities of the Erongo Region include agriculture, forestry, and fishing, mining and quarrying, manufacturing, tourism, and retail.

Mining plays a pivotal role in the economy of Namibia. Since independence, it has consistently been the biggest contributor to Namibia's economy in terms of revenue, and accounts for 25% of the country's income. Mining is one of the main contributors to GDP, and one of the largest economic sectors of Namibia. Mining is a prominent industry in the Erongo Region with the main commodities being uranium, gold, salt, and dimension stones, in addition to tin. Elsewhere, diamond, zinc, and copper are also important mineral commodities.

The economy of the Erongo Region is dominated by the local economies of Swakopmund and Walvis Bay. In the rural parts of the region, extensive livestock farming is a common activity, but intensive farming is also practiced along the lower part of the Swakop River, and at Omaruru. Several fresh crops are produced, mainly for local consumption.

In the Erongo Region, 67.5% of all households depend on salaries and wages as the main income (Namibian Statistics Agency, 2019). Exact figures do not exist, but this high percentage can be ascribed to the dominance of the mining, fishing, and manufacturing, and processing sectors, together with the prominence of state departments and the administrative sectors in the Erongo Region. A total of 12.6% of households receive their income from business activities (Namibian Statistics Agency, 2019).

5.22 Heritage and Culture

In Namibia, several mountains are closely coupled to heritage values. The Namib Desert has rich archaeological and heritage value and presents valuable information about the occupation of the area dating back 700 000 years. Archaeological remains in Namibia are protected under the National Heritage Act 27 (2004) and National Heritage Regulations (Government Notice 106 of 2005).

An archaeological field site visit and reconnaissance survey was conducted on ML 134 by Dr John Kinahan, from the 18th to 23rd October 2021 to identify possible sensitive archaeological sites that could be affected by the proposed Project activities. The surrounding area of the proposed Project is a long-established mining settlement, which lies close to (approximately 40 km west) the Dâures massif or Brandberg Mountain, which is considered a feature of archaeological importance, in the western parts of Namibia.

The archaeological assessment report, issued on the 1st of November 2021, forms the basis of recommended management actions to avoid or reduce potential negative impacts, as part of the environmental assessment, refer to Appendix H for the full archaeological assessment report.

The objectives of the archaeological assessment were to address the following elements:

- Identification and assessment of potential impacts on archaeological/heritage resources, including historical sites arising from the proposed exploration and mining activities
- Identification and demarcation of highly sensitive archaeological/heritage sites requiring special mitigation measures to eliminate, avoid, or compensate for possible destructive impacts
- Formulation and motivation of specific mitigation measures for the Project to be considered by the authorities for the issuance of clearance certificates
- Identify permit requirements as related to the removal and/or destruction of heritage resources.

The archaeological survey on ML 134 documented evidence of mid and late Holocene settlement within the broader ML, as well as evidence of more recent settlement, which is mainly in the form of cemeteries associated with the history of the mining settlement at Uis after 1946. The recent cemetery sites are not of archaeological significance and their conservation would be required under the Burial Place Ordinance (27 of 1966) rather than the National Heritage Act (27 of 2004). The earlier sites fall directly under the protection of the Heritage Act.

The dark red-brown monochrome painting of bundles at Site 312/889 has been identified as an area of potential heritage significance. As with nearby late Holocene seed gathering sites, it is likely that the focal area to which the rock art at Site 312/889 belongs, lies outside the ML 134 lease and probably to the north. Based on these observations the area's Holocene archaeology is unlikely to be affected by mining activities.

Further investigation of the lease may be warranted should the activities extend beyond the current active footprint. Mitigation of such extended activities that may affect protected archaeological sites will be guided by the required permitting from the National Heritage Council. In the meantime, the Proponent will adopt the Chance Finds Procedure as part of the EMP.

None of the recorded archaeological or heritage sites are found within the active mining area. See Figure 36 and Figure 37.

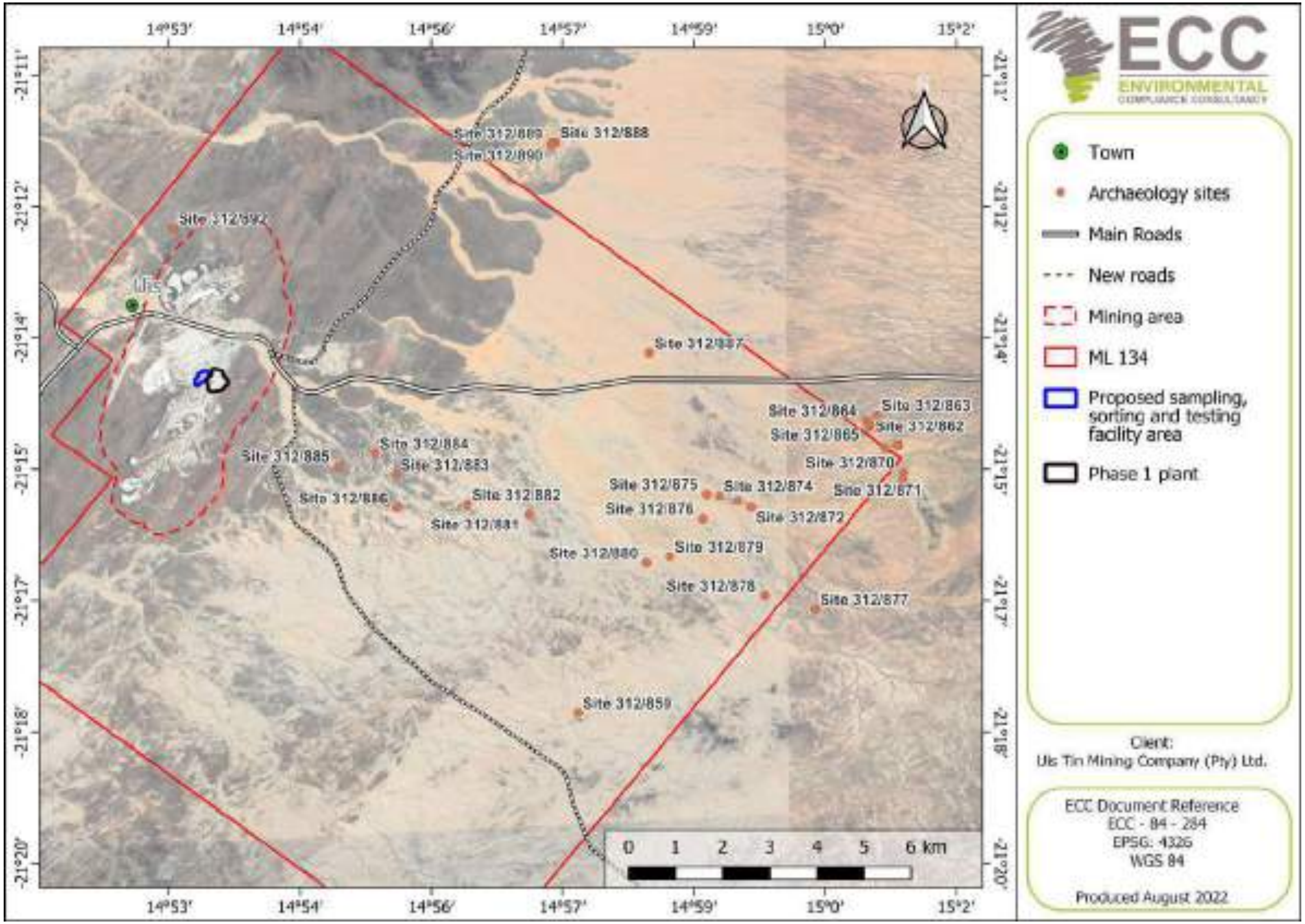

Figure 36 – Archaeologic sites in the Project area (Kinahan,2022)

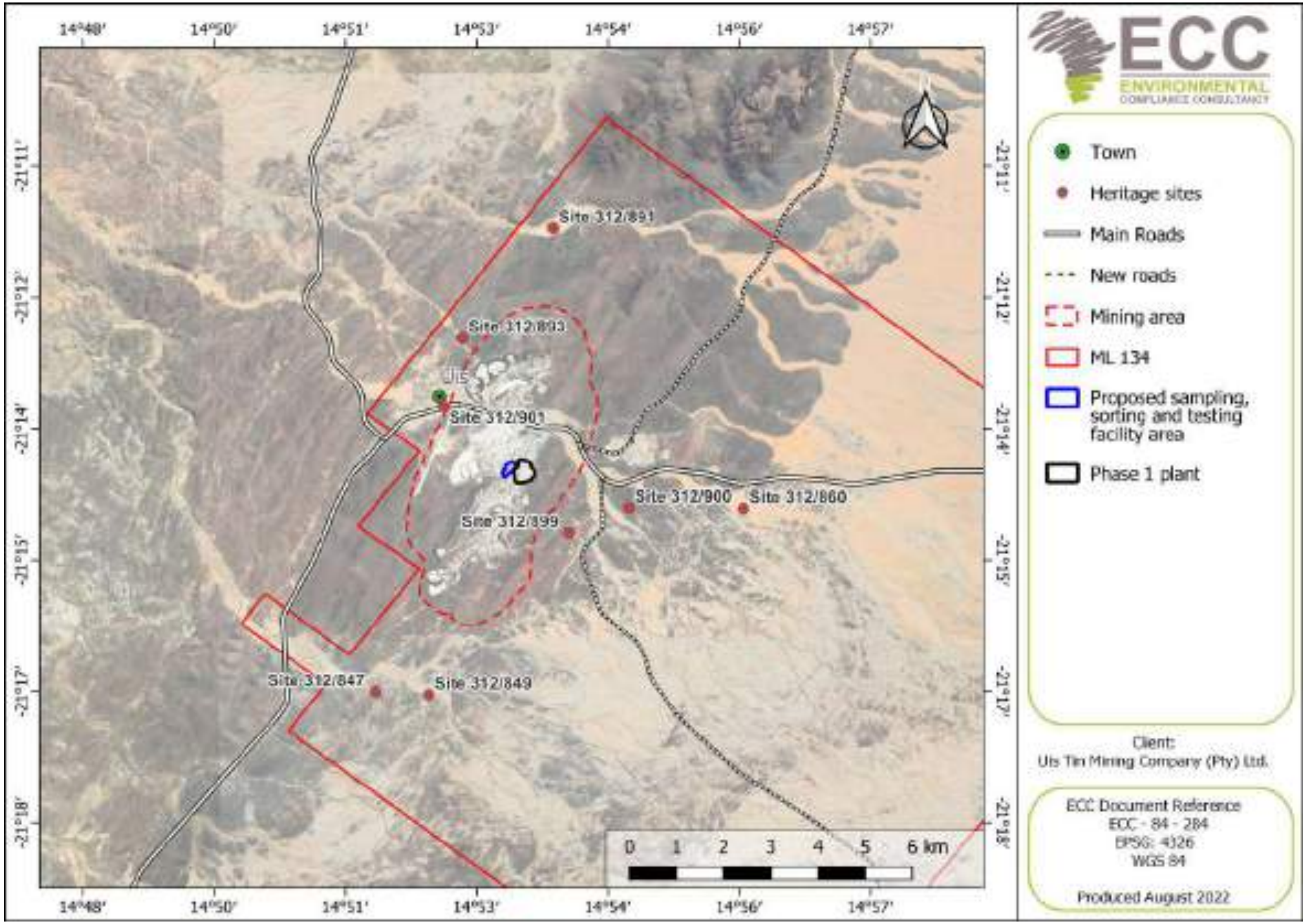

Figure 37 – Heritage sites in the Project area (Kinahan,2022)

5.23 NOISE AND VIBRATION

Noise is generally defined as unwanted sound transmitted through a compressible medium such as air. Sound, in turn, is defined as any pressure variation that the ear can detect. Human response to noise is complex and highly variable, as it is subjective rather than objective.

The IFC General Environmental Health and Safety Guidelines on noise addresses the impacts of noise beyond the property boundary of the facility under consideration and provides noise level guidelines. The IFC states that noise impacts should not exceed levels or result in a maximum increase above background levels of 3 dBA at the nearest receptor location off-site (IFC, 2007). For a person with average hearing acuity, an increase of less than 3dBA in the general ambient noise level is not detectable. The 3 dBA change is, therefore, a useful significance indicator for a noise impact.

5.23.1 ATMOSPHERIC ABSORPTION AND METEOROLOGY

Meteorological data purchased by Airshed for the past three years dating back to 2019 and used in their assessment will inform the baseline parameters. The measured data sets will indicate dominant wind flow patterns during day and night-time. Therefore, noise impacts can be predicted for Project activities.

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On a clear night, temperatures may increase with altitude, thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more notable during the night.

5.23.2 TERRAIN, GROUND ABSORPTION AND REFLECTION

Noise reduction caused by a barrier feature (i.e., natural terrain, installed acoustic barriers, buildings) depends on two factors, namely: the path difference of a sound wave as it travels around the barrier compared with direct transmission to the receiver, and the frequency content of the noise (Brüel & Kjær Sound and Vibration Measurement A/S, 2000). Sound reflected by the ground interferes with the directly propagated sound. The effect of the ground is different for acoustically hard (i.e., concrete or water), soft (i.e. grass, trees or vegetation), and mixed surfaces. Ground attenuation is often calculated in frequency bands, to consider the frequency content of the noise source and the type of ground between the source and the receiver (AirShed, 2021a).

The impact of an intruding industrial/mining noise on the environment rarely extends over more than 5 km from the source. The closest residential developments to the proposed project consist of Uis (~1.9 km to the northwest), Uis Mining Village (~1.7 km to the east) and Tatamutsi (~3.4 km to the east). Individual communal farmsteads also surround the project area.

5.23.3 METHODOLOGY APPLIED

Airshed was appointed to conduct the assessment of simulated noise levels, and reference was made to the IFC noise level guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night). To assess annoyance at nearby places of residence, the increase in noise levels above the baseline at NSRs were calculated and compared to guidelines published in the SANS 10103 (Airshed, 2022). See Appendix J for the noise specialist study conducted.

The baseline acoustic environment was described in terms of the location of NSRs, the ability of the environment to attenuate noise over long distances, as well as existing background and baseline noise levels. The following was found:

- The closest residential developments to the proposed project consist of Uis (~1.9 km to the northwest), Uis Mining Village (~1.7 km to the east) and Tatamutsi (~3.4 km to the east). Individual farmsteads also surround the project area, and
- Measured baseline noise levels were between 32.9 and 46.1 dBA during the day and between 25.6 and 55.2 dBA during the night.

Airshed identified sites to be monitored for day and night-time noise level measurements, for the noise baseline assessment. Survey sites were selected after careful consideration of future activities, accessibility, potential noise sensitive receptors, and safety restrictions. A total of six survey sites were selected. Local meteorological conditions and information on topography and local land use to populate the noise propagation model (CadnaA, ISO 9613). The propagation of noise was calculated over an area of 9.68 km east-west by 10.02 km north-south. The area was divided into a grid matrix with a 20-m resolution and NSRs were included as discrete receptors (Airshed, 2022).

A noise baseline survey was conducted on the 5th to 7th of May 2021, at designated points as shown in Figure 39 for the proposed Project site.

These sites were chosen based on the sensitivity of the areas in terms of proximity to properties within the Project site. Noise-sensitive receptors (NSRs) generally include private residences, community buildings such as schools and hospitals, and any publicly accessible areas. The ability of the environment to attenuate noise as it travels through the air was studied by considering land use and terrain. Figure 38 shows the sensitive receptors near and at the proposed Project site.

The noise sources of the proposed Project are typical of opencast mining and ore processing facilities. Sources of noise at the Project site will include the following:

- Drilling

- Blasting – the character of noise generated by blasting is mentioned. Blasting can cause noise and vibration, which can have an impact upon neighbouring noise receptors. Blasting usually results in both ground and airborne vibration
- Ore and waste handling (loading, unloading, dozing) in open pits, on waste dumps, and in crusher/plant areas
- Crushing and screening of ore
- Haul truck traffic
- Diesel mobile equipment use (including reverse warnings)
- Ore processing activities such as crushing, screening, and milling.

5.23.4 BASLINE RESULTS

Simulations indicate that exceedance of the daytime IFC guideline of 55 dBA for residential, educational, and institutional receptors will occur up to 450 m from the project site. The night-time simulated noise-levels exceed night-time IFC guidelines of 45 dBA for residential, educational, and institutional receptors up to ~1 km from the project site. The closest residential NSR is ~1.7 km east of the site, which is the Uis mining village. Figure 40 shows the simulated day-time noise levels recorded, while Figure 41 displays the simulated night-time noise levels recorded.

Figure 38 - Noise sensitive receptor locations (Airshed,2022)

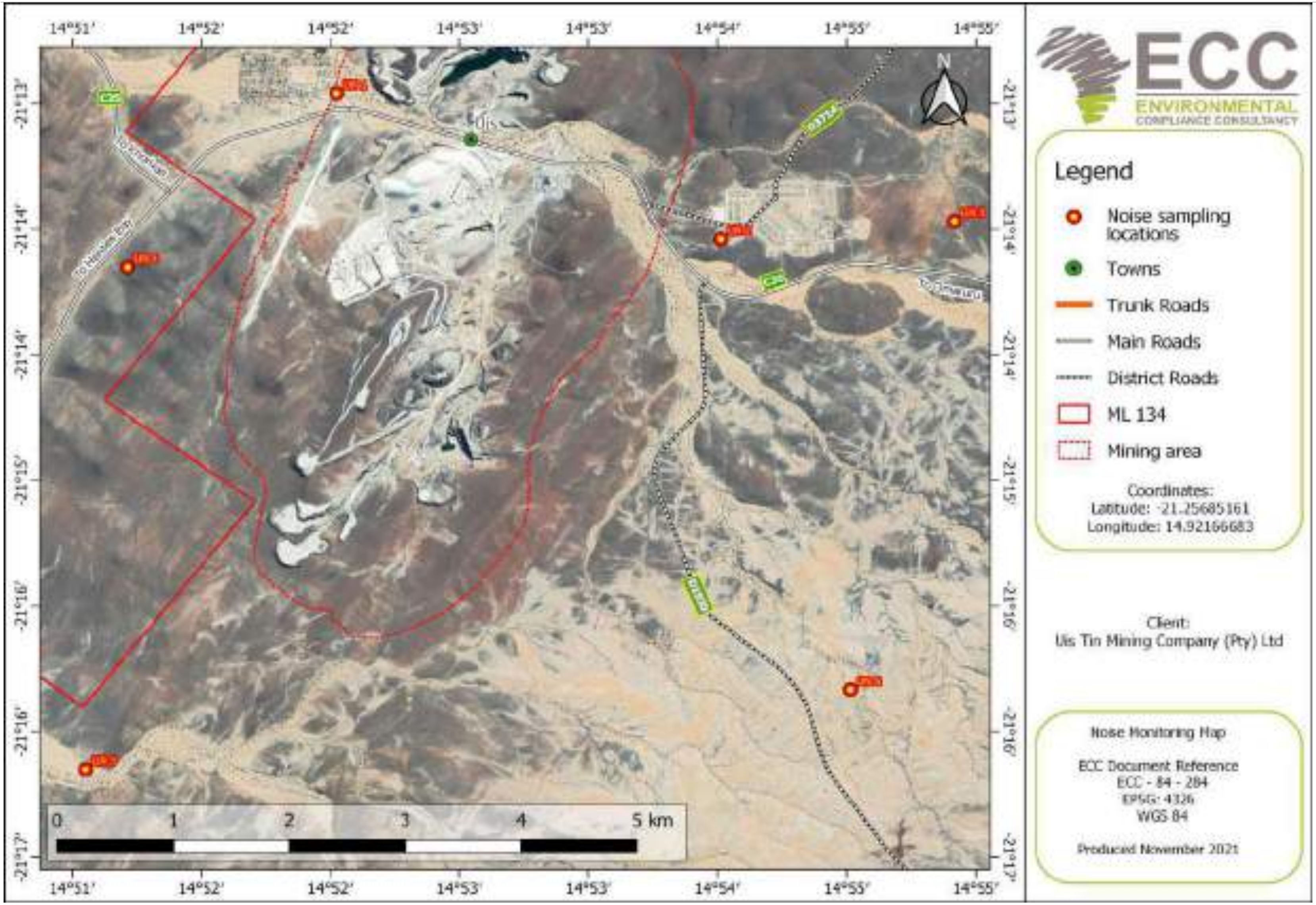

Figure 39 - Noise sampling points

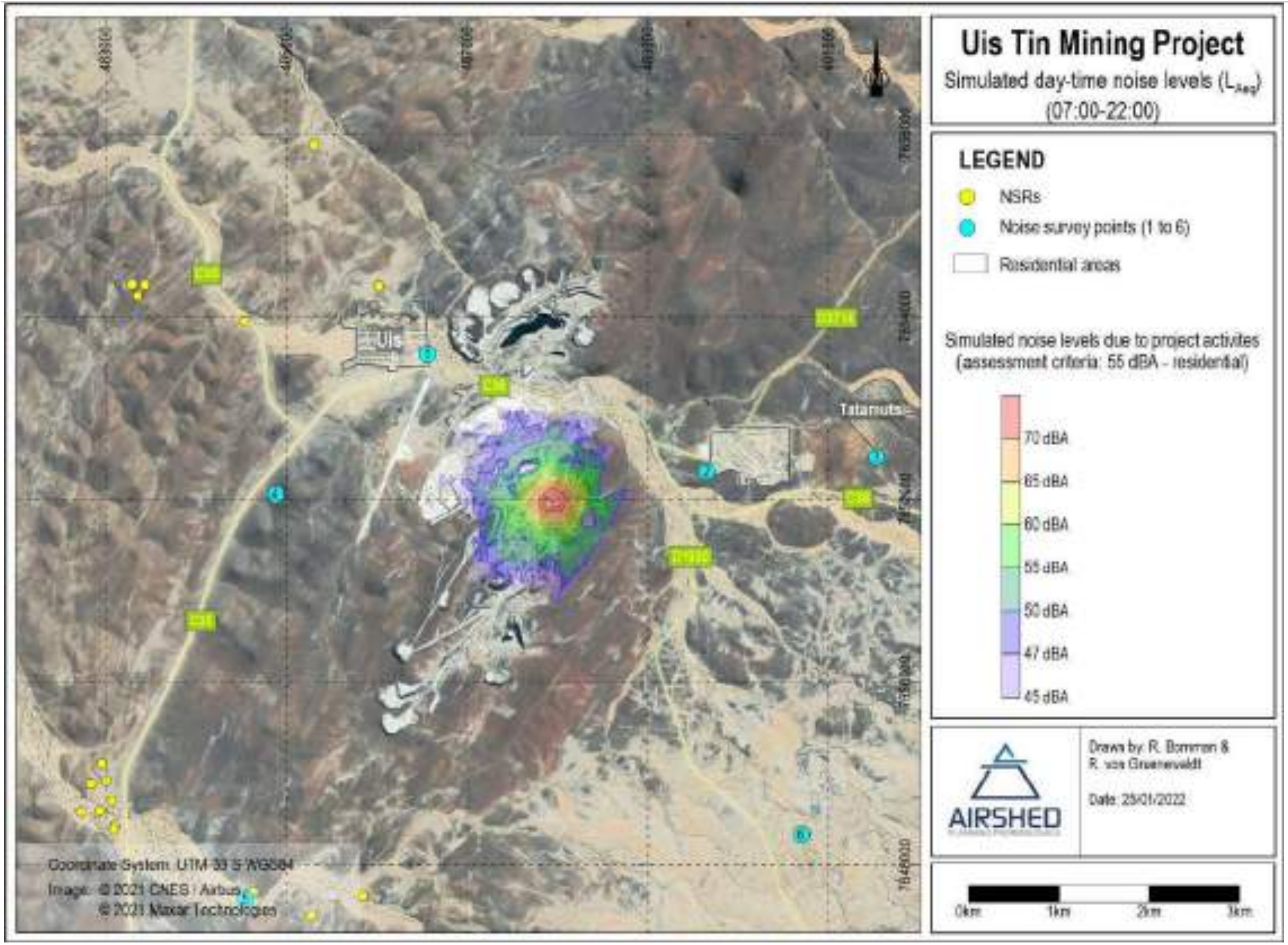

Figure 40 - Simulated day-time noise levels proposed operations (Airshed, 2022)

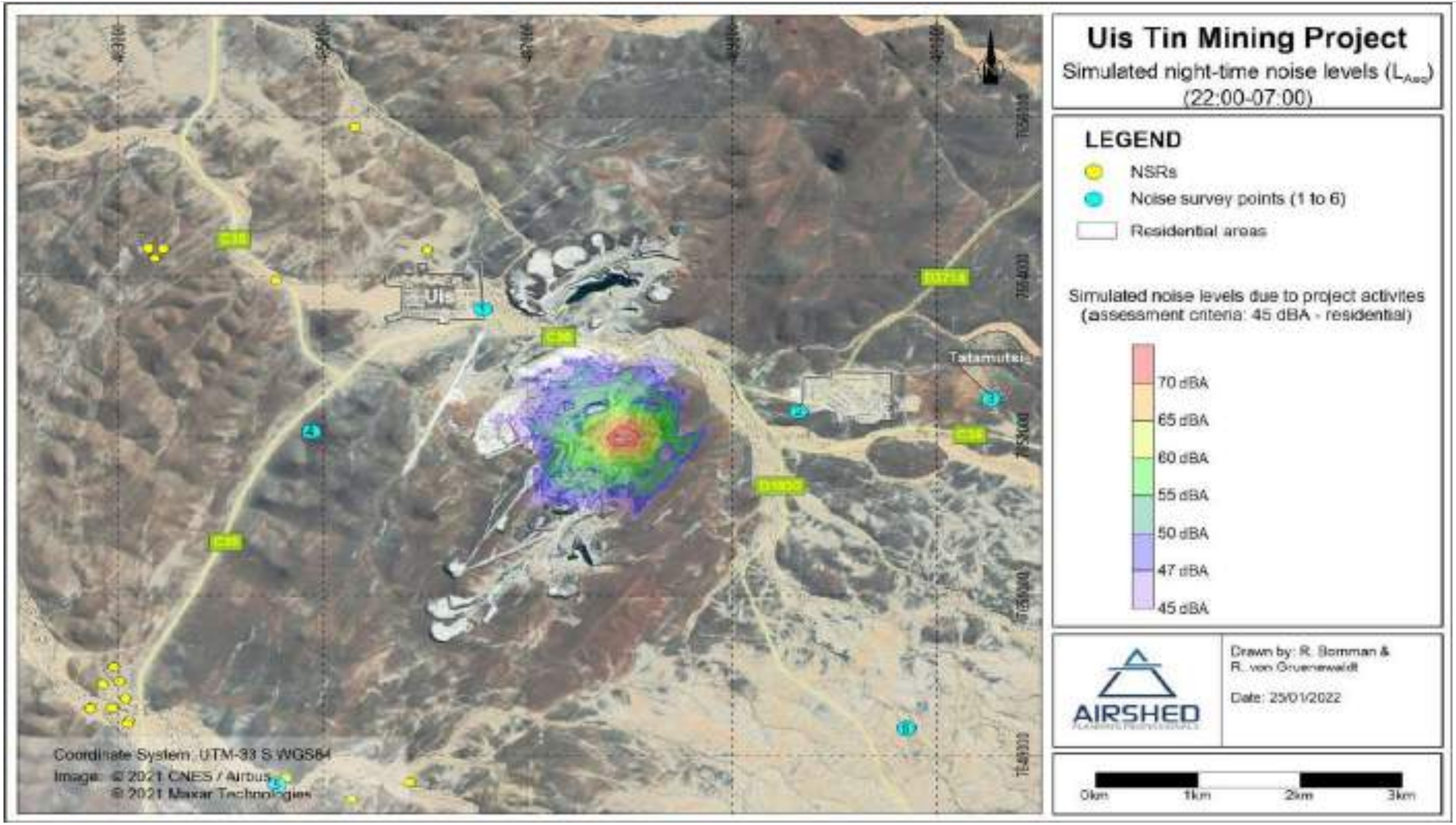

Figure 41 - Simulated night-time noise levels due to the proposed project operations

Table 14 - Summary of simulated noise levels results (provided as dBA) for the proposed project operations at NSRs within the study area (Airshed, 2022)

Noise Sensitive Receptor	Project operations [a]		Baseline		Increase Above Baseline [c]	
	Day	Night	Day	Night	Day	Night
Uis	18.2	19.2	39.2	44.1	0.0	0.0
Uis Mining Village ~1.7 km east of the plant	35.6	34.8	37.1	55.2	2.3	0.0
Tatamutsi	0	0	46.1	33.2	0.0	0.0
Individual homesteads at and to the east of sampling site 5 (NSR12, NSR13, NSR14, NSR15 – Figure 1)	0	0	32.9	47.5	0.0	0.0
Individual homesteads at sampling site 6 (NSR16 – Figure 1)	0	0	38.9	26.5	0.0	0.0
Individual homesteads ~1.6 km northwest of sampling site 5 (NSR0, NSR1, NSR2, NSR3, NSR4, NSR5, NSR6, NSR7 – Figure 1) (baseline measurements at site 5 assumed representative of the site)	0	0	32.9 [b]	47.5 [b]	0.0	0.0

Notes:

(a) Exceedance of day- and night-time IFC guideline for residential areas is provided in bold

(b) Baseline measurements based on closest sampling sites.

(c) Likely community response in accordance with the SANS 10103:

< 3 dBA	< 5 dBA	< 10 dBA	< 15 dBA	< 20 dBA
Change imperceptible	*No reaction*	*'Little' reaction with sporadic complaints*	*'Medium' reaction with widespread complaints*	*'Strong' to 'very strong' reaction with threats of community action or vigorous community action.*

5.24 VISUAL AND SENSE OF PLACE

The proposed UTMC Project is situated in a disturbed area enclosed by mountain ranges. No residential houses or tourist sites are accessed through the mine area. Therefore, there is no visual impact stemming from the proposed expansion Project on these receptors. The sense of place of the Project area has already been disturbed by the existing mining and processing activities of previous and existing mining as well as other industrial operations north of the mine site. The mountain ridge east of the mine area separates the mine from the informal residential area east of Uis. Similarly, the large WRD historically created by ISCOR effectively screens the viewshed of the western portion of Uis inhabitants and road users from the mine site. All road users of the C36 road driving past the entrance road of UTMC will not be able to see the entrance to the mine or any infrastructure of the mine as their view will be blocked by the infrastructure of the local brick factory.

Based on the modelled viewshed (Figure 42) of the proposed bulk sample, sorting, and test facility, the facility will not be of an intrusive nature within the existing township scenery, neither will it be visible from anywhere outside the immediate boundary of the mine area.

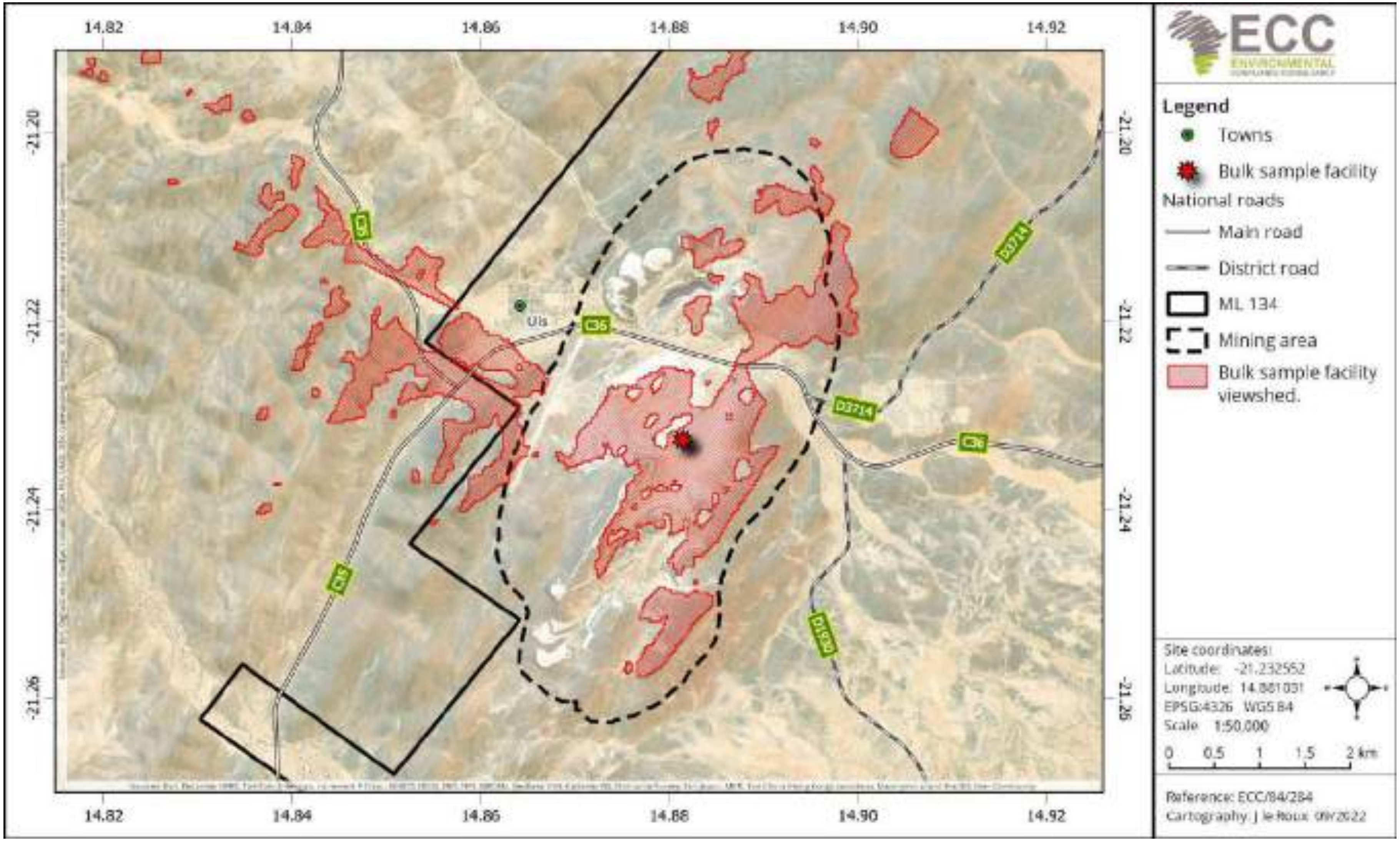

Figure 42 - Sense of place map of the bulk sample, sorting, and test facility as the highest point within the mining area for physical infrastructure.

The presence of the nearby airfield (Figure 43) west of the mine site is also not affected as it is visually screened from view by the interconnected historical WRD dump created by ISCOR and the mountain ridge west of the existing mine pits (V1 and V2).

Figure 43 - View of the airfield from the west facing slopes of the mountain ridge

The Brandberg mountain range which is located approximately 40 km west of Uis cis not easily visible from the Project site, unless one is standing on an elevated height looking westward.

5.24.1 LIGHTING

The night sky in the area is undisturbed. Namibia is known for its clear night skies and excellent stargazing settings. Artificial lighting, floodlights, and lighting for mining activities are not visible, although there are sites in proximity to the Project (north facing onto the C36: local brick factory) that are using lights for security purposes during nightfall. The baseline of undisturbed night skies will not be altered excessively during the construction and operations of the Stage II Project. Impacts associated with site lighting, and the appropriate management and mitigation measures are addressed in the EMP.

5.25 BIOPHYSICAL ENVIRONMENT BASELINE

5.25.1 CLIMATE AND METEOROLOGY

Namibia is arid to semi-arid and locally a hyper-arid country. Regionally, there is a growing demand for water due to climate change, population growth, economic development, and urbanisation, which increases pressure on existing water sources. The proposed Project is in central Namibia, an area that experiences generally hot daytime temperatures throughout the year, while the nights are mild to cool in winter.

Temperatures can reach up to 39.9°C while minimum temperatures can drop to 1.2°C and average temperatures fluctuate at 22.5°C (Airshed, 2022). The winter months, June, July and August, are rainless and the average daytime temperatures range between 18 to 22 degrees Celsius. Rain is more frequent in the months from January to March as shown by recent historic data (Figure 44). In general terms the climate of Uis can be described as hot and dry, with more than 300 sunshine days per year. Solar radiation ranges from 6.0 - 6.4 kWh/m2/day (see Figure 45).

Winds of a westerly direction are predominant with average wind speeds between 12 and 19 km/h, mainly because of its proximity to the Atlantic Ocean and Namib Desert. The months of October to January are known to have the strongest winds. Wind can occur any time of the day and the most predominant wind directions for this area are ENE, SW and SSW (Figure 46).

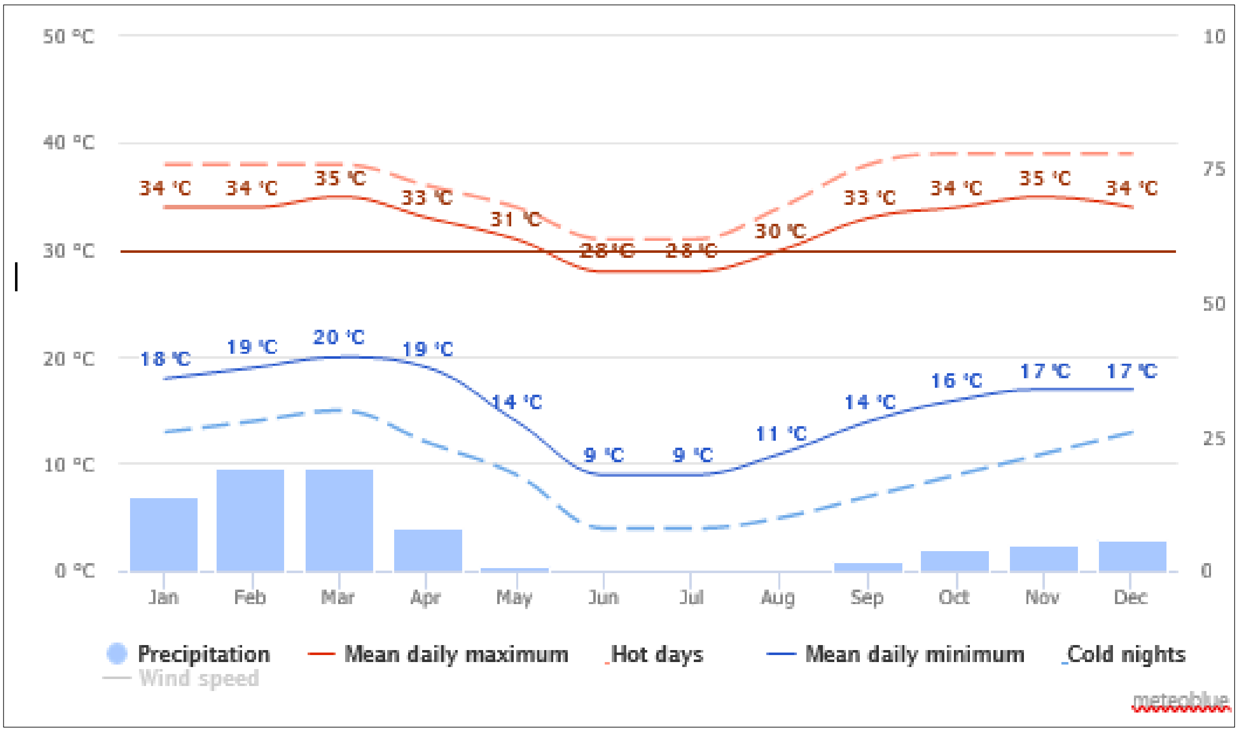

Figure 44 - Average temperatures and precipitation at Uis (source: Meteoblue)

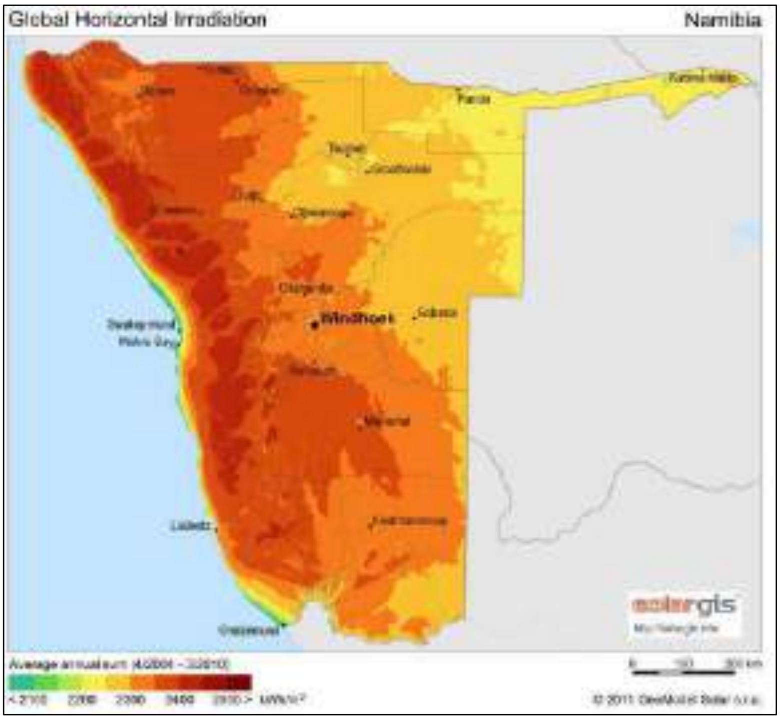

Figure 45 - Solar radiation Namibia (source: atlas of Namibia)

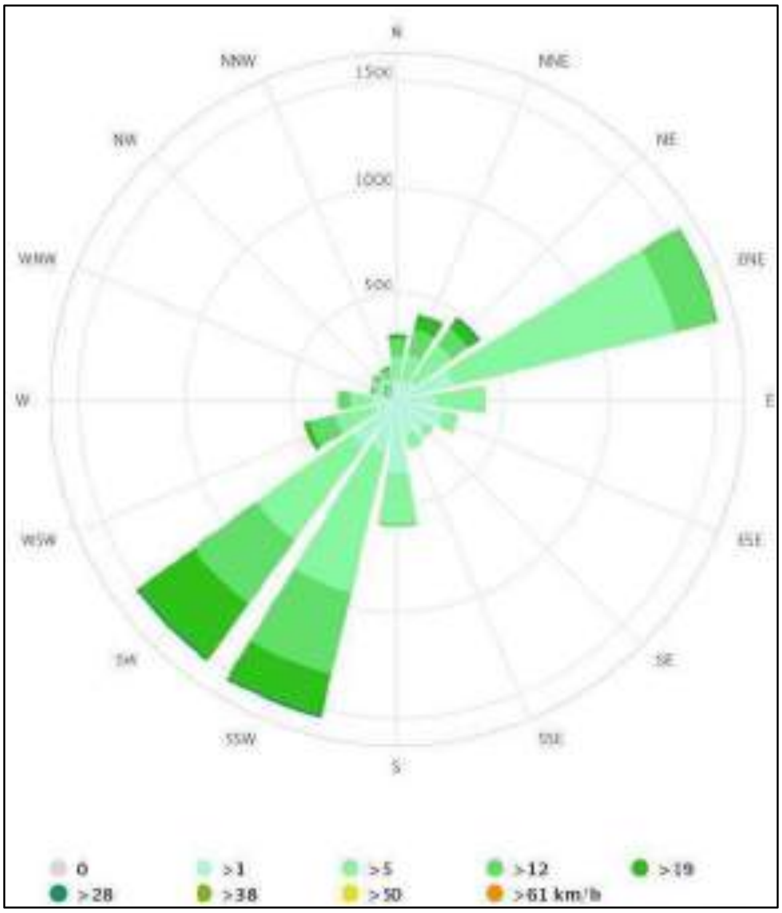

Figure 46 - Wind direction and speed for Uis, Erongo Region (source: Meteoblue, 2021)

5.25.2 AIR QUALITY

Since February 2019, Environmental Compliance Consultancy has been conducting environmental monitoring and assessments for UTMC, for the purpose of tracking depositional dust, at 14 dust monitoring stations located on the Project site. Air quality monitoring is crucial for determining the potential impacts that planned mining and processing operations may have on an environment.

5.25.3 AIR QUALITY BASELINE CHARACTERISATION OF THE UIS AREA

Baseline characterisation was done by Airshed who conducted the air quality specialist study for the ESIA. The below baseline features apply.
The wind field in the area is dominated by winds from the southwest during the day and night, with an increase in winds from the south-southwest and south during the night. Day- and night-time average wind speeds are 4.6 m/s and 5.0 m/s respectively. Calm conditions occur 3.0% of time during the day and 2.5% during the night. On average, air quality impacts are expected to be slightly more notable to the north and north-east of the Project.

The predominant south-south-westerly, southerly and north-north-easterly winds in the study region may be explained by the topography of the study area. Uis is ~800 m above sea level with the highest point at 900 m above sea level. The terrain is fairly flat in the immediate vicinity of the plant site, with steeper and higher relief areas confined to the northeast and south. The highest wind speeds (more than 6 m/s) were recorded during summer and springtime and are mostly from the south-southwest and southwest.

Maximum, minimum, and mean temperatures were given as 39.9°C, 1.2°C and 22.5°C respectively from the WRF data for the period Jan 2018 to Dec 2020.

Average annual rainfall at Uis town for the period 2009 to 2021 was given as 656 mm, with most rain recorded during the summer (December to March) and least during the winter months from May to September.

The main pollutant of concern in the region is particulate matter (TSP; PM10 and PM2.5) resulting from vehicle entrainment on the roads, windblown dust, mining and exploration activities.

Sources of atmospheric emissions in the vicinity of the Project include small-stock farming, small-scale mining, activities of the Namclay Brick and Pavers factory, dust generated from historically mined areas and, to a lesser extent, emissions from vehicle tailpipes along the C36 and D1930 public roads. Other regional sources that may have an influence on the ambient air quality around the Project are biomass burning (natural bush fires or those employed for agricultural purposes) and de-bushing to increase the grazing capacity of farmland. Given these activities, it is expected that fugitive dust may be present during dry, windy conditions. However, the contribution of all these sources to existing ambient air quality is considered very low, especially in a low-density population area such as the one where the Uis Tin Mine is located.

Regional scale transport of mineral dust and ozone (due to vegetation burning) from the north of Namibia is a potential contributing source to background PM concentrations.

There is no ambient air quality data available for the study site. PM concentrations measured as part of the SEMP AQMP monitoring network were limited to the coastal towns of Swakopmund, Walvis Bay and Henties Bay with a station in the central western part of the region on the farm Jakalswater. None of these locations are representative of the air quality in the Uis area.

The potential expected sources of dust include but are not limited to construction activities on settling ponds, the return water dam (RWD); mineral material handling and processing, the construction of a bulk sampling, sorting and testing facility; and mining activities within V1 and V2 open pits) such as drilling, blasting, and hauling. Therefore, depositional dust monitoring station locations were based on the proposed infrastructure locations likely to generate dust, considering prevailing wind. Figure 34 shows the locations of the 14 dust fall sampling locations. Initially eight dust buckets were installed around the site in February of 2019; thereafter six buckets were added to the pool of dust monitoring buckets.

Dustfall deposition rates from the Uis monitoring network (Figure 48) are generally low for the sampling period and well within the dustfall limit of 600 mg/m2/day (adopted limit for residential areas) and 1 200 mg/m2/day (adopted limit for non-residential areas), with the exception of AQ 01 (5 exceedances in 2020 and 4 exceedances in 2021), AQ 05 (2 exceedances in 2019, 5 exceedances in 2020 and 1 exceedance in 2021), AQ 08 (1 exceedance in 2019) and AQ 14 (1 exceedance in 2020) (Figure 47).

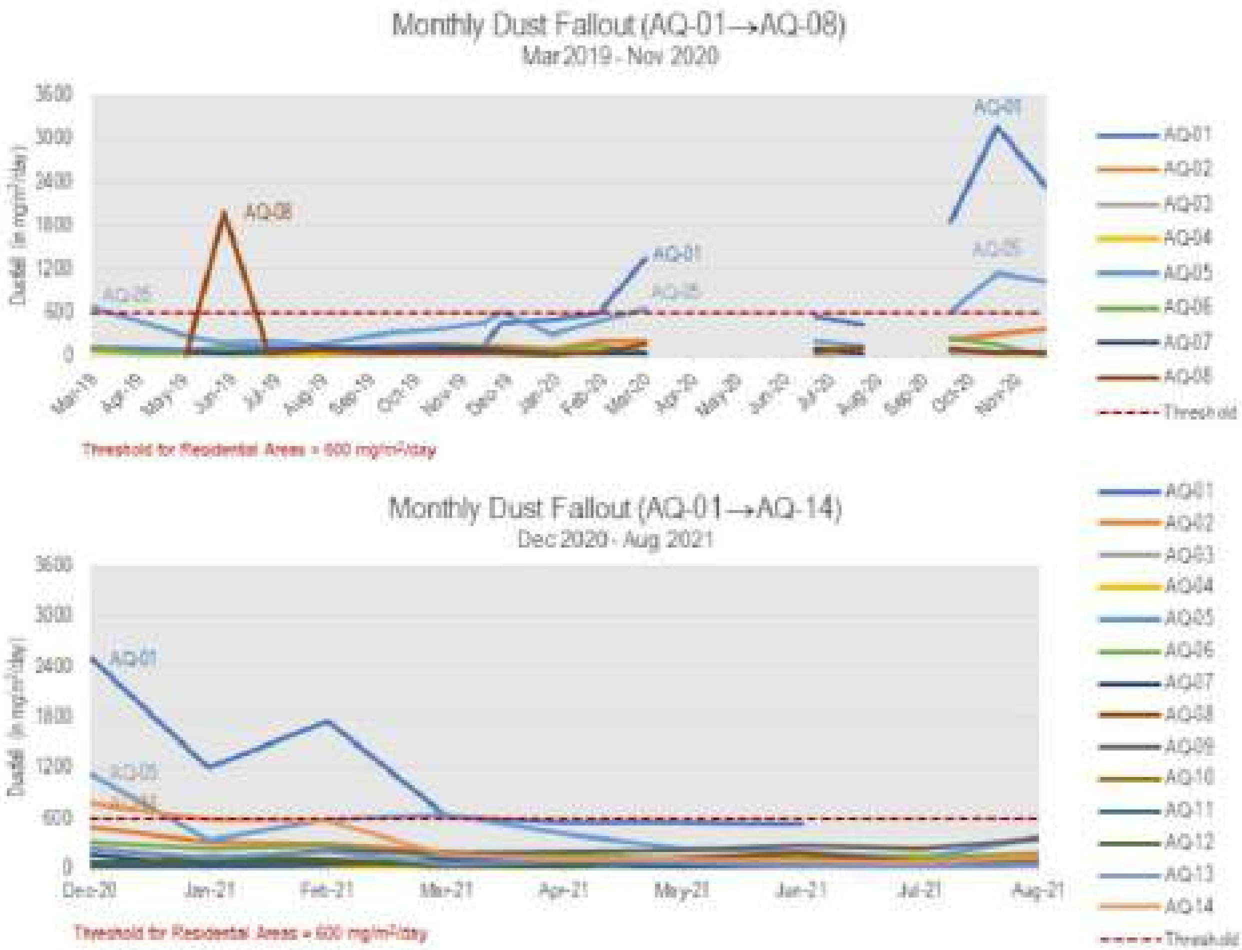

Figure 47 - Dustfall rates for Uis Tin Mine monitoring (March 2019 - August 2021)

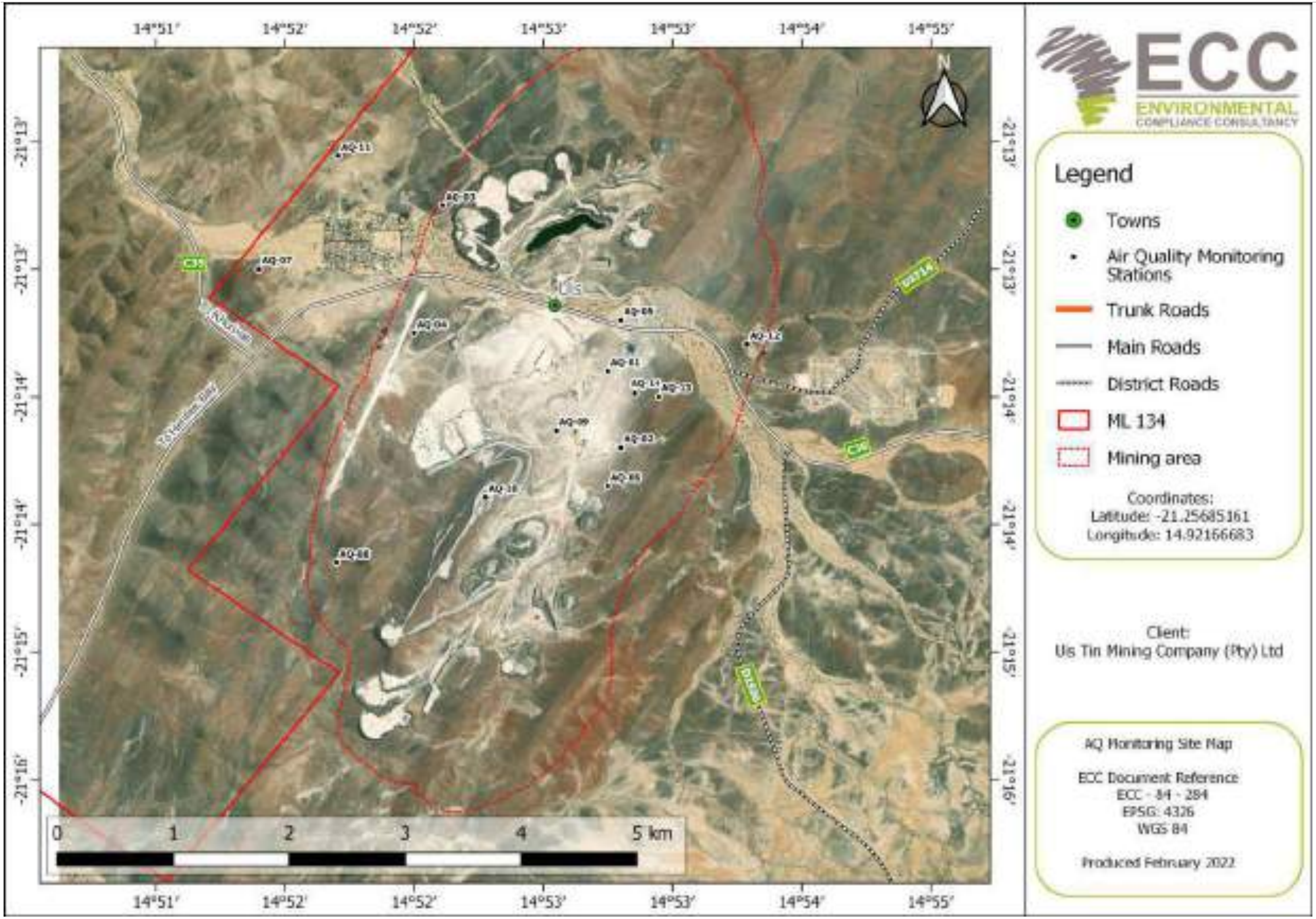

Figure 48 - A map showing the dust-fall monitoring locations

Natural environments are complex systems that can be affected by anthropogenic interference such as mining activities, including mineral exploration. To understand the confounding factors and interpret the findings based on the baseline of the receiving environment, deductive and inductive approaches are used. The wind vectors, topography (i.e. mountains and valleys), seasonal rainfall, and drought are identified as the potential factors that are likely to influence air quality. Dust particulate matter fallout can be correlated with wind direction and speed. Wind direction and speed are the primary factors determining the distance of travel of a dust particle and the distribution of particles falling out. See Section 5.25.

Moreover, as part of the ESIA for the proposed Stage II, an air quality specialist study was deemed necessary to confirm the baseline characterisation of the site and determine the potential impacts of atmospheric pollution from the Project. Airshed Planning Professionals were engaged to model and assess and provide a technical report for the air quality assessment. The ambient air quality guidelines of the IFC and EHS guidelines of 2007 was applied to the assessment.

The Uis Mining Project does not have a weather station and use was made of Weather Research and Forecasting Model (WRF) modelled meteorological data for the Uis study area for the period 1 January 2018 – 31 December 2020, to (a) describe the dispersion potential of the site and (b) as input into the ADMS dispersion model (Airshed, 2022).

5.25.4 ASSUMPTIONS ON THE MODELLING RESULTS

Only routine emissions were estimated and modelled and was done for the provided operational hours. Working hours were provided 24-hour days, 7 days a week for open-pit mining activities. Total operating hours per annum were provided for different sections of the plant operating on a continual basis. This was used as the worst-case scenario base (Airshed, 2022).

To determine the significance of air pollution impacts from the Project, emissions were estimated for a baseline scenario (based on Stage I throughputs) and a Project scenario (based on Stage II throughputs) (Airshed, 2022).

The modelling results do not include a determination of the significance of air pollution impacts on the immediate environment from the bulk sampling, sorting and testing facility in the absence of operational design data.

5.25.5 AIR DISPERSION MODELLING

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the Project's emissions sources on the receiving environment. In the quantification of emissions, use was made of emission factors that associate the quantity of release of a pollutant to the activity. Emissions were calculated using emission factors and equations published by the United States Environmental Protection Agency (US EPA) and Environment Australia

(EA) in their National Pollutant Inventory (NPI) Emission Estimation Technique Manuals (EETMs) (Airshed, 2022).

The significance of air quality impacts from the tin and tantalum process was assessed, considering both an unmitigated and mitigated scenario.

5.25.6 BASELINE CHARACTERISATION FROM MODELLING

Air pollutants will originate from opencast operations at two pit areas (V1 and V2 open pits) and the associated processing operations including the bulks sampling, sorting and testing facility. Ore and waste will be removed with haul trucks and taken to the Run of Mine (RoM) stockpile area and waste rock dump (WRD)/Co-disposal facility (CPF), respectively. Ore will be crushed at a primary crusher whereafter it will undergo secondary crushing, fines crushing and milling at the processing plant. The waste from the processing plant will be hauled to the CPF. Ore production is currently estimated at 567 kilo tonnes per annum (ktpa); this will increase to 850 ktpa to support the expanded materials handling and concentrating plant (MHCP) capacity (Airshed, 2022).

Considering the surface wind field (variability of direction and the extent of crosswind spreading), over the Project site, various colours were used to depict the different categories of wind speeds and direction. See Figure 49 and Figure 50.

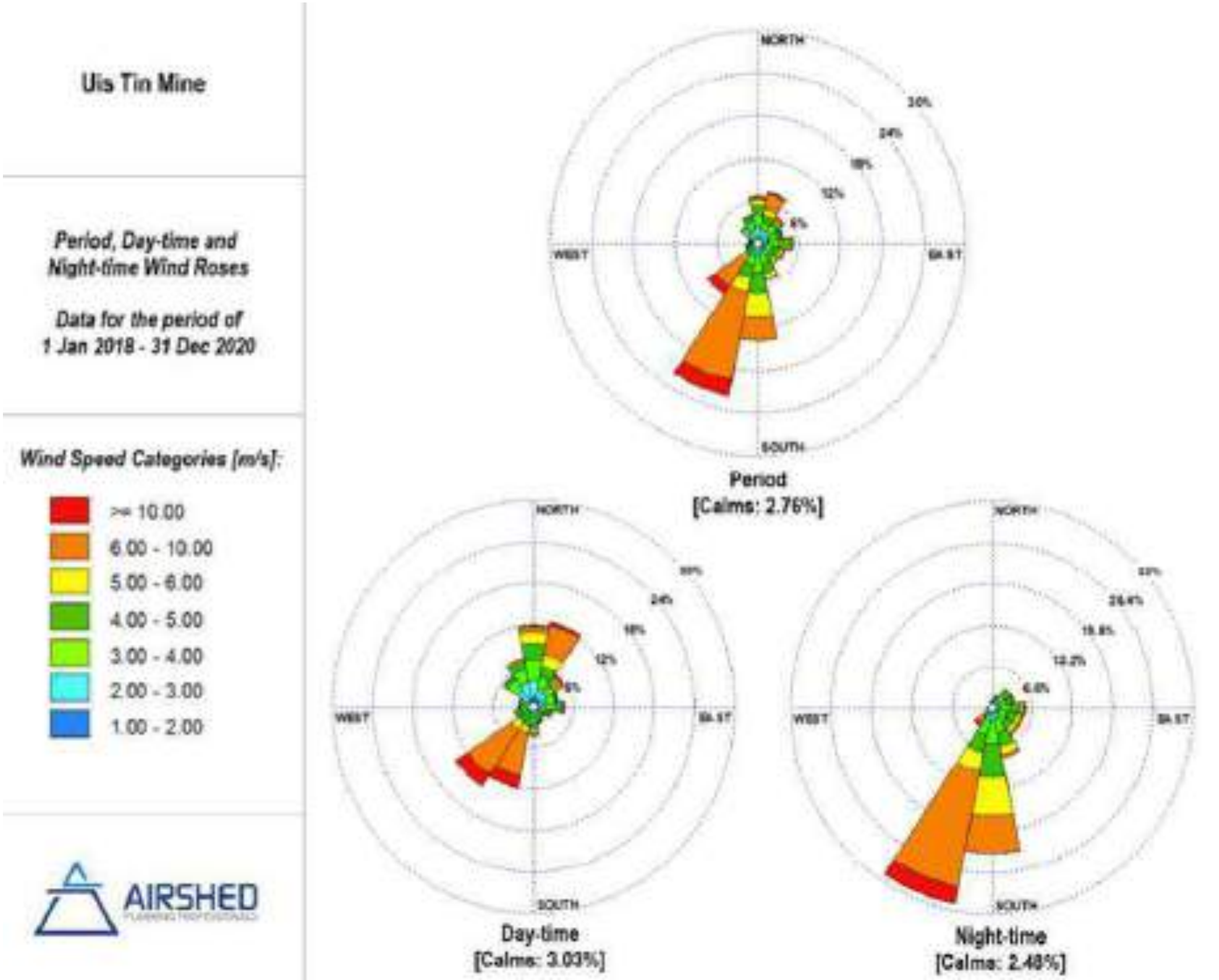

Figure 49 - Period, day- and night-time wind roses based on modelled WRF data for Uis Tin Mine (Jan 2018 - Dec 2020) (Source: Airshed, 2022)

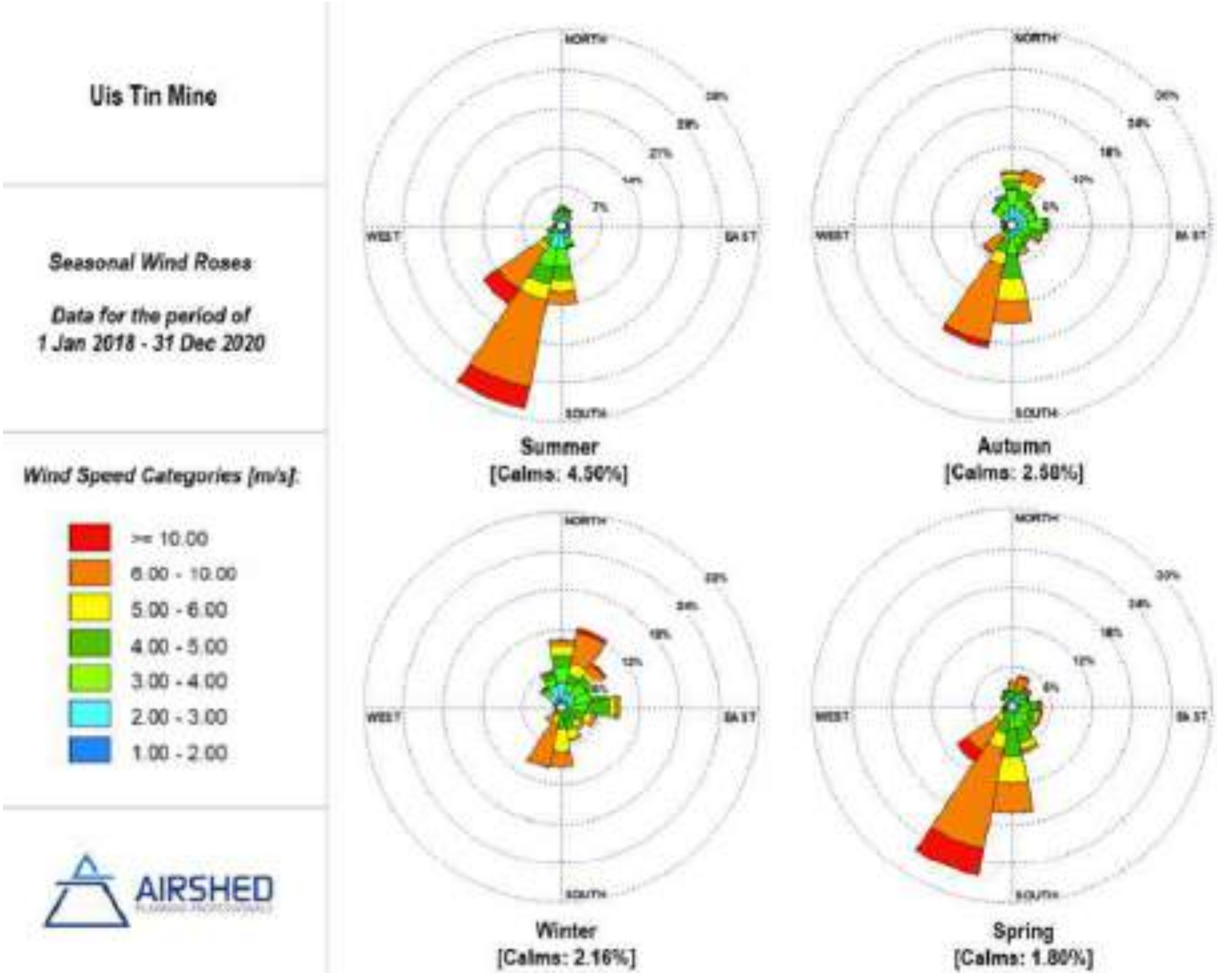

Figure 50 - Seasonal wind roses based on modelled MM5 data for Uis Tin Mine (Jan 2018 - Dec 2020) (Source: Airshed, 2022)

The main pollutant of concern in the region is particulate matter (TSP; PM10 and PM2.5) resulting from vehicle entrainment on the roads, windblown dust, mining, and exploration activities (Airshed, 2022).

Sources of atmospheric emissions in the vicinity of the Project include small-stock farming, small-scale mining, activities of the NamClay Brick and Pavers factory, dust generated from historically mined areas, and to a lesser extent, emissions from vehicle tailpipes along the C36 and D1930 public roads.

Other regional sources that may have an influence on the ambient air quality around the Project are biomass burning (natural bush fires or those employed for agricultural purposes) and de-bushing to increase the grazing capacity of farmland. Given these activities, it is expected that fugitive dust may be present during dry, windy conditions. However, the contribution of all these sources to existing ambient air quality is considered very low, especially in a low-density population area such as the one where the Uis Tin Mine is located (Airshed, 2022).

The wind field in the area is dominated by winds from the southwest during the day and night, with an increase in winds from the south-southwest and south during the night. Day- and night-time average wind speeds are 4.6 m/s and 5.0 m/s respectively. Calm conditions occur 3.0% of time during the day and 2.5% during the night. On average, air quality impacts are expected to be slightly more notable to the north and north-east of the general area. The highest wind speeds (<6m/s) occur during summer and springtime and mostly from south-westerly to south-south-west directions, which may be explained by the topography of the study area (Airshed, 2022).

Construction Phase

The construction phase during Stage II was designed to allow pre-assembly while the plant is in operation. Construction work include civil works, in-plant erection, piping, erection of conveyors and gantries, conveyor mechanical installation, and electrical, control and instrumentation work. The largest construction works (in terms of land area) are the construction of a new secondary crushing and screening plant and a DMS feed stockpile. The total land area was determined from georeferenced site plans as approximately 1 320 m2.

Operational Phase

Two mining scenarios were assessed to determine the increase in impacts due to the Project, namely a Baseline scenario and Project Scenario. It was assumed that Stage I throughputs as provided in the Definitive Feasibility Study (DFS) summary represent the Baseline scenario (current mining rates) and that Stage II throughputs represent the Project scenario (future mining rates required to support the expanded MHCP). V1 and V2 opencast areas were assumed to be mined concurrently in a 57: 43 tonnage split.

Airshed (2022) quantified emissions for the Uis project which were restricted to fugitive releases (non-point releases) with particulates the main pollutant of concern. Emissions were quantified based on provided information on mining rates and the mine layout plan. See specialist study report for the detailed methodology framework used (Appendix I).

Table 15 - Summary of emissions due to baseline and project scenarios (Airshed, 2022)

Description	Baseline Scenario						Project Scenario					
	Unmitigated			Mitigated			Unmitigated			Mitigated		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
In-pit (including drilling)	51.34	75.99	186.41	49.91	62.24	139.35	52.76	89.71	233.38	50.62	69.10	162.84
Blasting	0.06	1.04	24.40	0.06	1.04	24.40	0.06	1.04	24.40	0.06	1.04	24.40
Materials handling	0.72	4.74	10.01	0.36	2.37	5.01	1.32	8.74	18.47	0.54	3.55	7.51
Crushing and screening	16.85	85.84	572.61	7.00	15.93	182.35	25.27	112.01	796.40	0.43	3.74	12.80
Unpaved roads	8.77	87.69	306.84	2.19	21.92	76.71	13.15	131.46	459.99	3.29	32.86	115.00
Wind erosion	3.59	12.97	49.91	3.59	12.97	49.91	3.59	12.97	49.91	3.59	12.97	49.91
Total	**81**	**266**	**1141**	**63**	**114**	**468**	**96**	**354**	**1573**	**58**	**121**	**363**

Notes:

(a) BASELINE: Mitigation includes 75% control efficiency (CE) on unpaved surface roads and 50% CE on unpaved in-pit roads (using water sprays), 50% CE on primary and secondary crushing and materials handling operations (using water sprays), >75% CE for tertiary and fines crushing and screening (wet process)

(b) PROJECT: Mitigation includes all control measures listed in (a), but with 99% CE on primary and secondary crushing operations (dual scrubber).

The contributions of individual source groups to total tons per annum for the baseline and Project scenarios are illustrated in Figure 51 below.

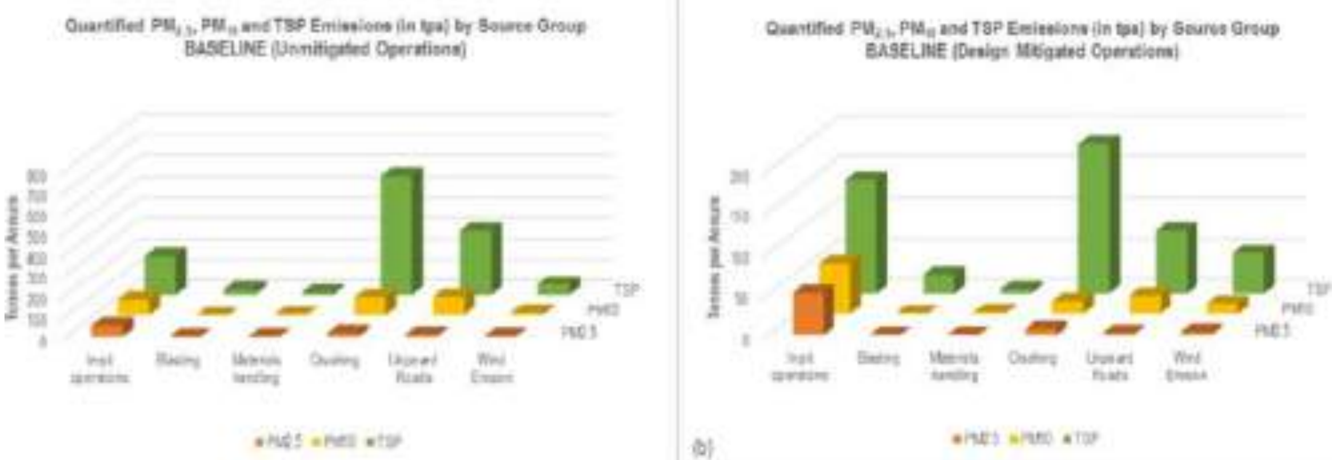

Figure 51 - Contribution of particulate emissions per source group (unmitigated – left and mitigated - right) (Airshed, 2022)

Table 16 - calculated emission rates due to unmitigated and mitigated activities for the incremental and cumulative bulk sampling, sorting and testing facility scenarios respectively from emissions source groups (source: Airshed, 2022).

Description	Incremental Project Scenario						Cumulative Project Scenario					
	Unmitigated			Mitigated			Unmitigated			Mitigated		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
In-pit (including drilling)	–	–	–	–	–	–	52.76	89.71	233.38	50.62	69.1	162.84
Blasting	–	–	–	–	–	–	0.06	1.04	24.4	0.06	1.04	24.4
Materials handling	0.04	0.28	0.58	0.02	0.14	0.29	1.36	9.02	19.05	0.56	3.69	7.8
Crushing and screening	0.91	1.83	25.55	0.46	0.91	12.78	26.18	113.84	821.95	0.89	4.65	25.58
Drying and Classifying	1.44	2.97	7.32	0.12	0.24	0.53	1.44	2.97	7.32	0.12	0.24	0.53
Unpaved roads	0.33	3.33	11.72	0.08	0.83	2.93	13.48	134.79	471.71	3.37	33.69	117.93
Wind erosion	0.02	0.15	0.30	0.02	0.15	0.30	3.61	13.12	50.21	3.61	13.12	50.21
Total	**3**	**9**	**45**	**1**	**2**	**17**	**99**	**364**	**1628**	**59**	**126**	**390**

Notes:

(a) Incremental Project: Mitigation includes 75% control efficiency (CE) on unpaved surface roads (using water sprays), 50% CE on primary and secondary crushing and materials handling operations (using water sprays), >90% CE for drying, classifying and product storage (using fabric filters)

(b) Cumulative Project: Mitigation includes all control measures listed in (a), but with additional measures listed under Table 13 (PROJECT scenario).

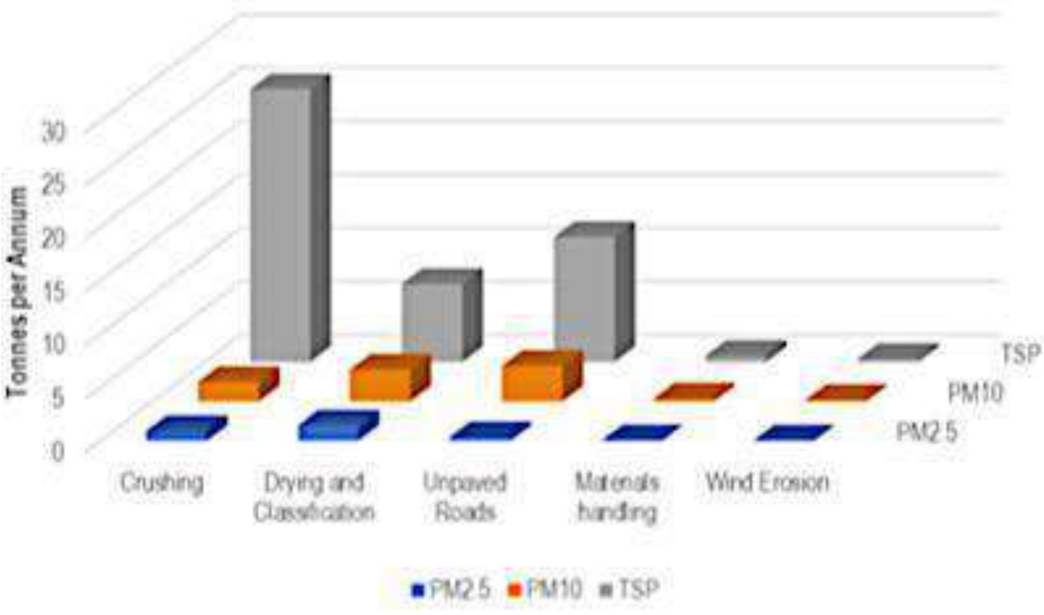

Figure 52 - Contribution of particulate emissions per source group (unmitigated)

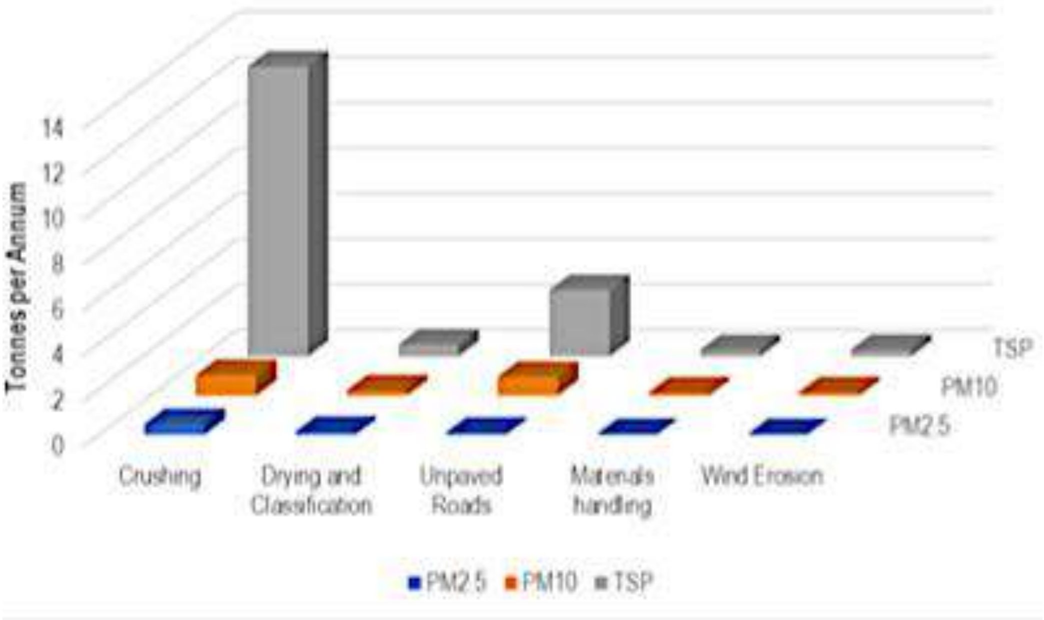

Figure 53 - Contribution of particulate emissions per source group (design mitigated) Source: Airshed, 2022

Based on the simulation results (

Figure 52 and Figure 53) from the source group emissions modelling the biggest emissions sources are from the unpaved roads, the crushing plant, and the drying and classification plant at the bulk sampling, sorting, and testing facility. However, the modelled results are lowered with mitigation measures put in place.

5.26 STORMWATER CONTROL

Nurizon Consulting Engineers used the approach of Best Practice Guidelines G1 Stormwater Management as published by the South African Department of Water Affairs (DWA) to formulate the stormwater management plan strategy for the Stage II expansion Project. The strategy is to separate and channel dirty water from clean water. Dirty water will be channelled in a closed system into a pollution control dam (PCD) and clean water will be channelled from the site and discharged into the natural environment.

The facilities are delineated in dirty and clean stormwater run-off areas, with the dirty water collected and conveyed to the PCD for re-use. The mine will be operated as a closed system (in terms of the dirty stormwater run-off); with stormwater run-off within the dirty water areas being collected and conveyed to a silt trap and discharged into the PCD. The water from the PCDs will be transferred to the RWD re-used. No water from the PCDs will be released into the environment. Clean stormwater runoff is diverted away from the Project site into existing streams (Nurizon, 2020). Additional functional stormwater control will be applied to the perimeter of the new bulk sampling, sorting and testing facility similar to the current processing plant CWC designs. The purpose of stormwater.

5.26.1 STORMWATER MANAGEMENT PRINCIPLES PROPOSED

The following basic principles form an integral part of the development of the stormwater management strategy:

- Dirty and clean stormwater catchments shall be delineated and separated so that clean stormwater run-off is diverted around contaminated areas and to natural water courses
- Impacts on the existing groundwater resources, in terms of quality and quantity shall be minimised through the use of impermeable membranes in the design of dirty stormwater infrastructure, i.e. High-density polyethylene (HDPE) liners for the pollution control and concrete linings for the dirty water drainage channels
- Prevention of erosion of the existing water courses, particularly at clean stormwater system discharge points
- Mitigation of flooding to neighbouring properties in the areas due to the proposed facility's footprint and activities
- The required capacity of the individual elements comprising the dirty water system considered the following:
    - Projected water balance, with the aim of retaining the contaminated (dirty) water within a closed system
    - Maximum estimated stormwater peak flow generated by a storm event with a 1 in 50-year recurrence interval
    - Maximum estimated 24-hour runoff volume with 1 in 50-year recurrence interval.

5.26.2 FLOOD LINE DETERMINATION

Flood line determination is used to indicate the level to which a certain flood magnitude will inundate an area along the stream or any watercourse, or which area of land will fall within the floodplain of a particular flood frequency. Flood frequency or the return period (T) is the average period over n-years, which an event repeats or exceeds itself; it may be described as the percentage of the annual probability of the occurrence of a flood event (Digby Wells, 2022).

To determine the extent of flood events within natural drainage systems in the project area, baseline hydrology and climatic data was used to model flood event behaviour by Digby Wells. Catchment delineation was undertaken using Ras Mapper software and referenced to the central meridian 33 Datum.

Peak flows were also determined using land cover and soil type parameters which informed the modelling data. Six catchments were delineated for modelling purposes for the streams that are in the vicinity of the project area. The focus of the study was to delineate the 1:50 and 1:100-year return period flood lines in the vicinity of the mine. The peak discharge characteristics of each catchment is shown in the final flood determination report prepared by Digby Wells (2022) (Appendix F).

5.26.3 ASSUMPTIONS AND LIMITATIONS OF THE STUDY

The following are assumptions made by the specialist and limitations of the study:

- The flood lines were developed for environmental and indicative purposes only and not for detailed engineering design purposes;
- The main watercourses traversing through the project area have been considered for flood lines modelling, as it has a sizable contributing catchment. However, drainage lines north of the project area originating along the boundaries of the site were not modelled because they were deemed small and therefore could not collect any significant amount of runoff that can potentially cause flooding;
- It is assumed that survey data obtained from the client is accurate and an up-to-date representation of the ground-level terrain;
- A steady-state (1-dimensional/1-D) hydraulic model was run, which assumes that flow is continuous at the determined peak flow rates. This is a conservative approach, which results in higher flood levels than if transient state modelling was performed;
- The lidar survey provided is assumed to represent the terrain/elevations and other features correctly (e.g., berms);
- The berms should cover all the areas that are prone to flooding, such as the open pit;

The flood lines were modelled for sections of the unnamed streams traversing through the project area and only within the boundaries of the surveyed area;

- No abstractions from the river section or discharges into the river section were considered during flood modelling; this study only focuses on the flood lines scenarios and;
- Although flood calculations are executed with great care, the possibility always exists that a more severe flood could occur or that flooding as a result of non-hydrological events could take place.

5.26.4 RESULTS

Although the final modelled results indicate that both the 1:50 and 1:100-year flood events will mostly not inundate the mining areas, the lidar survey conducted indicates a potential flood risk at Berm 8 is possible. Indicative results show that both the 1:50 year and 1:100 year modelled flood events will surpass the edge of Berm 8 and flow into the mining pit area which is at a lower natural ground level (805.6 m AMSL) than the natural ground level at Berm 8 (807 m AMSL). The specialist recommendation would then be to extend Berm 8 further around the mine area see Figure 54.

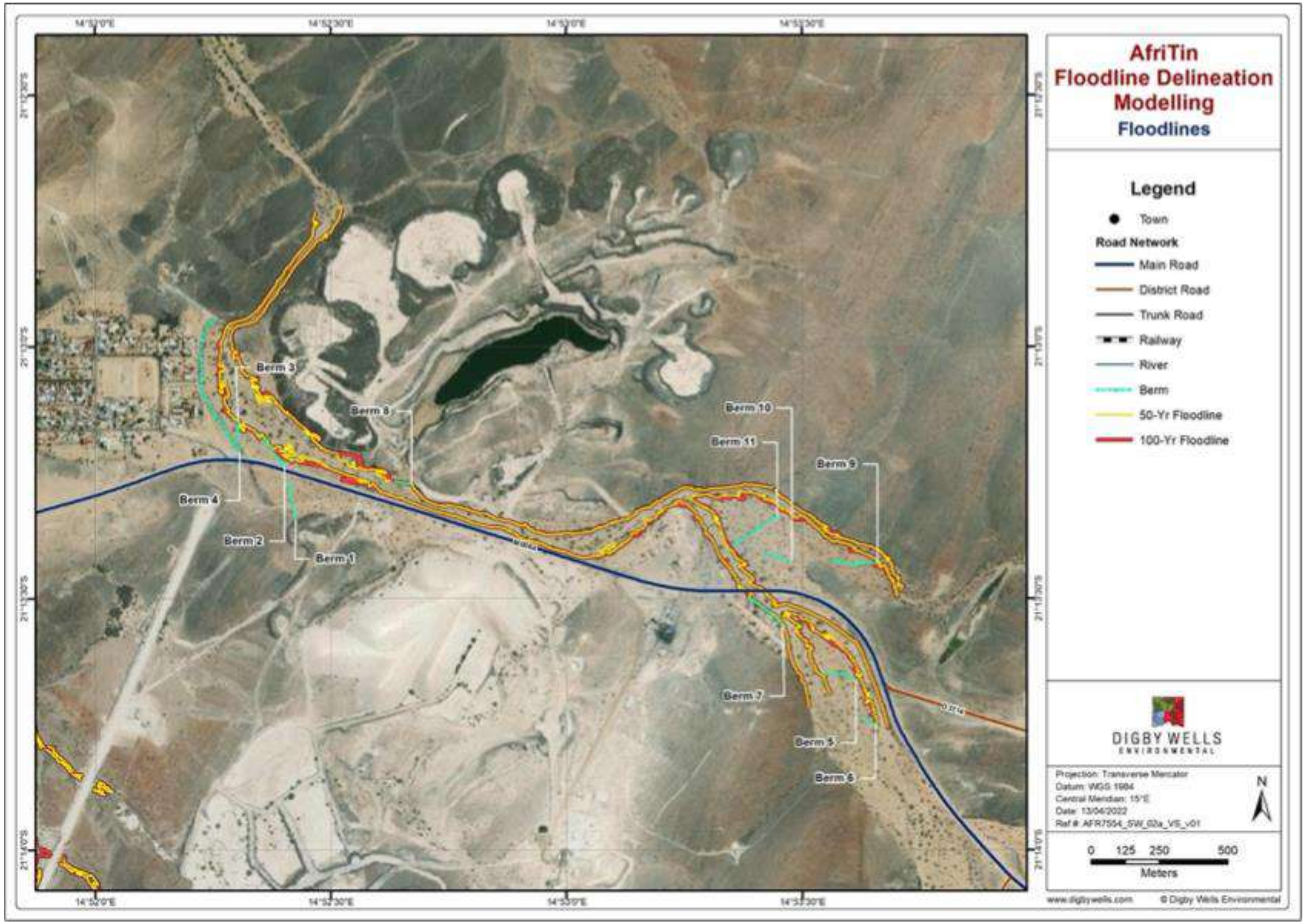

Figure 54 - Floodlines for the 1:50-year and 1:100-year flood events (Digby Wells, 2022)

6 IMPACT IDENTIFICATION AND EVALUATION METHODOLOGY

6.1 INTRODUCTION

Chapter 2 provides an overview of the approach used in this ESIA process, and details each of the steps undertaken to date. Predication and evaluation of impacts is a key step in the ESIA process. This chapter outlines the methods that will be followed to identify and evaluate the impacts arising from the proposed Project. The findings of the assessment will be presented in the full assessment report.

This chapter provides comprehensive details of the following:

- The assessment guidance that will be used to assess impacts
- The limitations, uncertainties, and assumptions with regards to the assessment methodology
- How impacts will be identified and evaluated, and how the level of significance will be derived
- How mitigation will be applied in the assessment, and how additional mitigation will be identified
- The cumulative impact assessment (CIA) method that will be used.

The aims of this assessment will be to determine which impacts are likely to be significant; to scope the available data and identify any gaps that need to be filled; to determine the spatial and temporal scope; and to identify the assessment methodology.

The scope of the assessment was determined through undertaking a preliminary assessment of the proposed Project against the receiving environment, and was obtained through a desktop review, available site-specific literature, monitoring data, and site reports, as set out in this scoping report.

6.2 ASSESSMENT GUIDANCE

The following principal documents will be used to inform the assessment method:

- International Finance Corporation standards and models, in particular performance standard 1: ‘Assessment and management of environmental and social risks and impacts’ (International Finance Corporation, 2012 and 2017)
- International Finance Corporation Cumulative Impact Assessment (CIA) and Management Good Practice Handbook (International Finance Corporation, 2013)
- Namibian Draft Procedures and Guidance for EIA and EMP (Republic of Namibia, 2008).

6.3 LIMITATIONS, UNCERTAINTIES AND ASSUMPTIONS

The following limitations and uncertainties associated with the assessment methodology will be considered in the assessment phase:

- Topic specific assessment guidance has not been developed in Namibia. A generic assessment methodology will be applied to all topics using IFC guidance and professional judgement
- Guidance for CIA has not been developed in Namibia, but a single accepted state of global practice has been established. The IFC's guidance document (International Finance Corporation, 2013) will be used for the CIA.
- The assessment of impacts related to air quality, soil and potential groundwater contamination from acid de-containment from the bulk sample, sorting and testing facility is based on conceptual engineering designs of the flotation circuit. The definitive design of the circuit will be completed in due course but will not materially influence the process flow of the ore extraction regime.

6.4 ASSESSMENT METHODOLOGY

The ESIA methodology applied to this assessment has been developed by ECC using the International Finance Corporation (IFC) standards and models, in particular Performance Standard 1: 'Assessment and management of environmental and social risks and impacts' (International Finance Corporation, 2017); Namibian Draft Procedures and Guidance for EIA and EMP (Republic of Namibia, 2008); international and national best practice; and over 25 years of combined ESIA experience. The methodology is set out in Figure 55 and Figure 56.

The evaluation and identification of the environmental and social impacts require the assessment of the Project characteristics against the baseline characteristics, ensuring that all potentially significant impacts are identified and assessed. The significance of an impact is determined by taking into consideration the combination of the sensitivity and importance/value of environmental and social receptors that may be affected by the proposed Project, the nature and characteristics of the impact, and the magnitude of any potential change. The magnitude of change (the impact) is the identifiable changes to the existing environment that may be negligible, low, minor, moderate, high, or very high; temporary/short-term, long-term or permanent; and either beneficial or adverse.

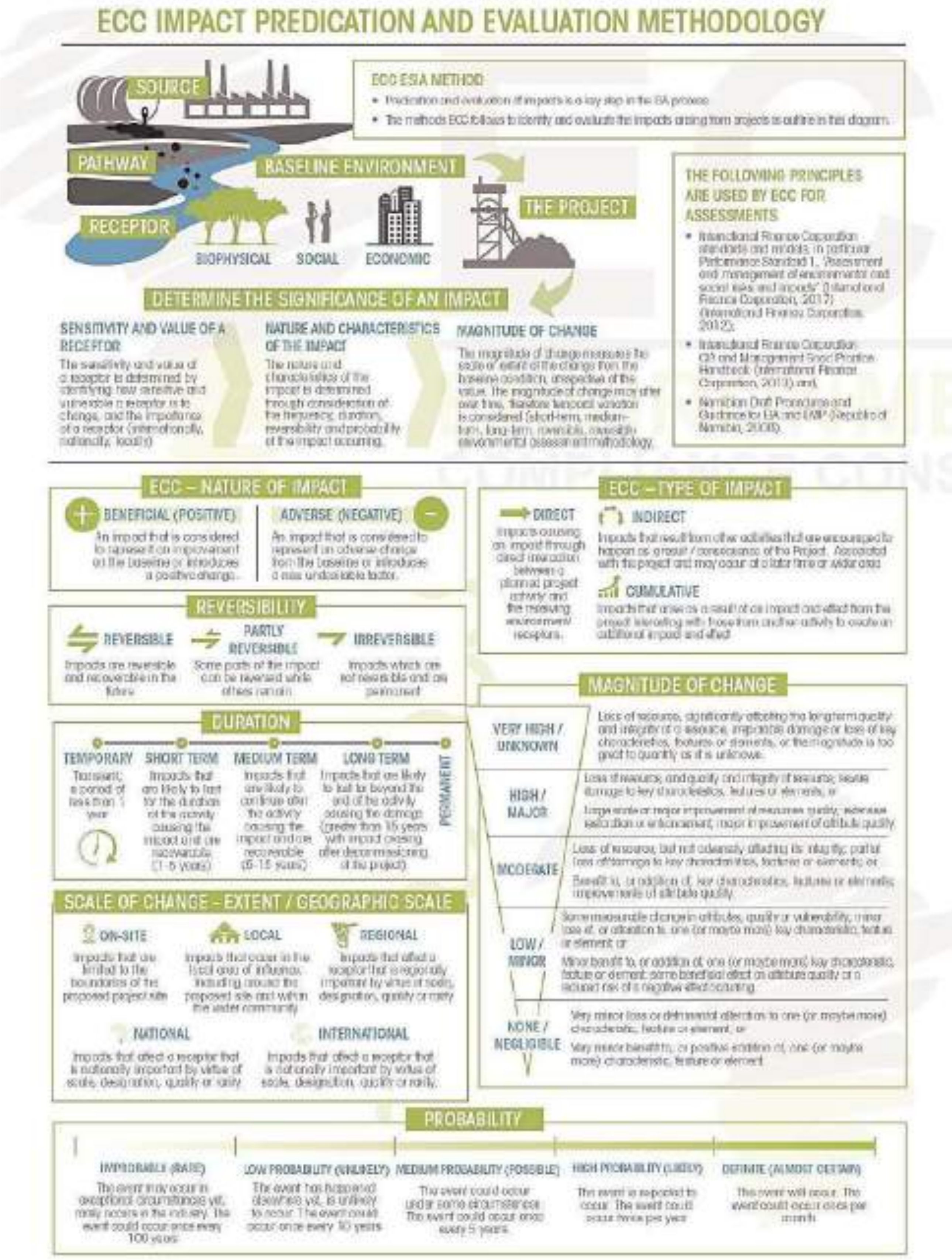

Figure 55 - ECC ESIA methodology based on IFC standards

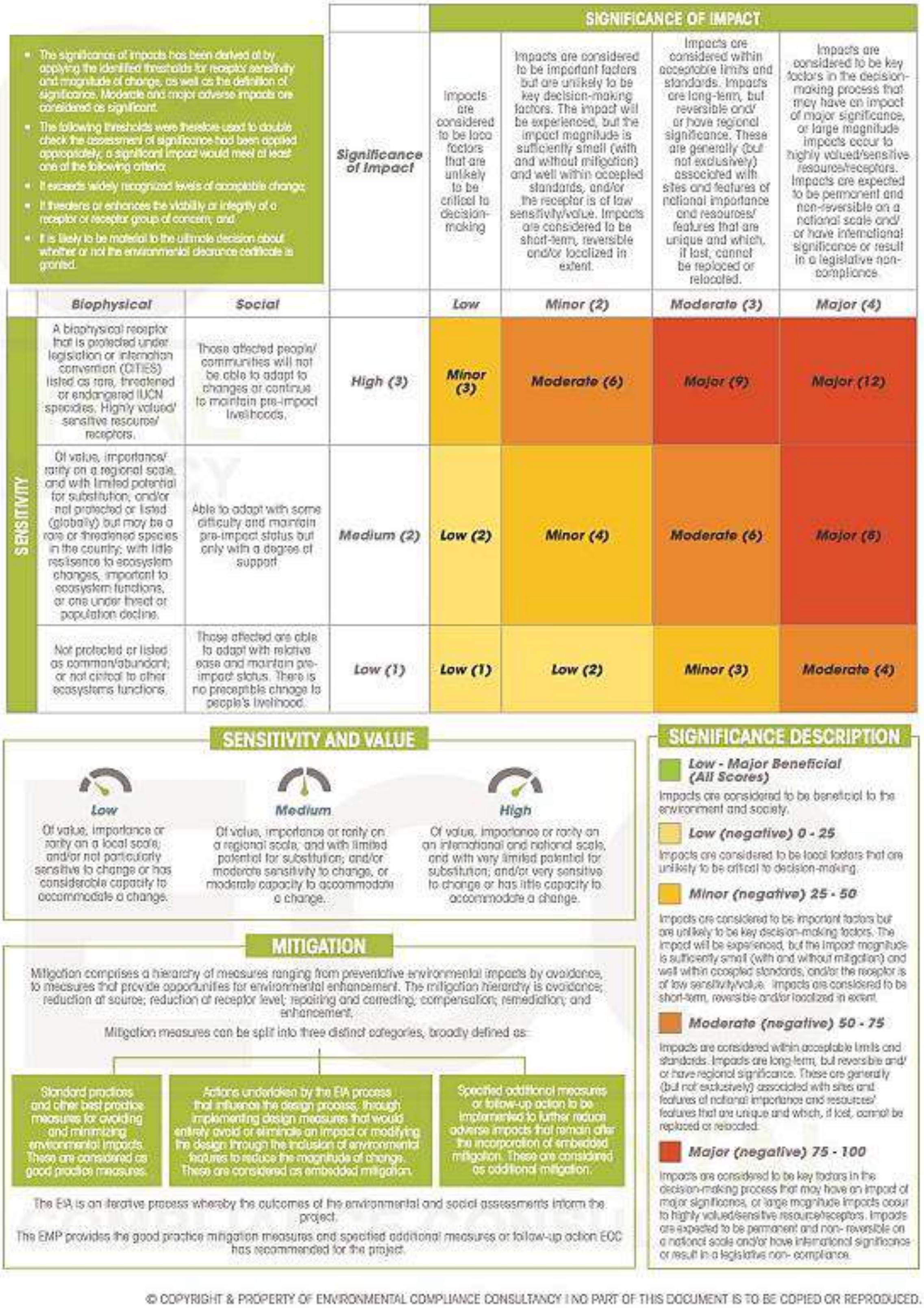

Figure 56 - ECC ESIA methodology based on IFC standards

6.5 MITIGATION

Mitigation comprises a hierarchy of measures ranging from preventative environmental impacts by avoidance, to measures that provide opportunities for environmental enhancement. The mitigation hierarchy is: avoidance; reduction at source; reduction at receptor level; repairing and correcting; compensation; remediation; and enhancement.

Mitigation measures can be split into three distinct categories, broadly defined as:

1. Actions undertaken by the ESIA process that influence the design process, through implementing design measures that would entirely avoid or eliminate an impact or modifying the design through the inclusion of environmental features to reduce the magnitude of change. These are considered as embedded mitigation
2. Standard practices and other best practice measures for avoiding and minimising environmental impacts. These are considered as good practice measures
3. Specified additional measures or follow-up action to be implemented, in order to further reduce adverse impacts that remain after the incorporation of embedded mitigation. These are considered as additional mitigation.

The ESIA is an iterative process whereby the outcomes of the environmental assessments inform the Project. Considerable mitigation has been built into the proposed Project, as potentially significant adverse environmental impacts have been identified and design changes have been identified to overcome or reduce them.

The final EMP (Appendix A) provides the good practice measures and specified additional measures or follow-up action.

Embedded mitigation and good practice mitigation will be considered in the assessment. Additional mitigation measures will be identified when the significance of impact requires it and causes the impact to be further reduced. Where additional mitigation is identified, a final assessment of the significance of impacts (residual impacts) will be carried out, taking into consideration the additional mitigation.

7IMPACT ASSESSMENT FINDINGS AND MITIGATION

The impact assessment considered stakeholder input and specialist studies, and a preliminary environmental management plan was produced. The report focuses on significant impacts and presents a summary of impacts that are not considered significant. Each potential significant or sensitive impact is summarised, including the activity that would cause the impact, potential impacts, mitigation measures, sensitivity of receptors, severity, duration, and probability of impacts, and significance before and after mitigation. The report is structured to describe potential socioeconomic and biophysical impacts.

The structure of the assessment Chapter as per the main impacts assessed are as follows:

1. Socio-economic: Economic
2. Socio-economic: Social
3. Biophysical environment

7.1 IMPACTS NOT CONSIDERED SIGNIFICANT

As a result of an iterative project evolution process, mitigation has been incorporated and embedded into the project plan, thereby designing out potential environmental and social impacts or reducing the potential impact so that it is not significant. The EMP provides best practice measures, management, and monitoring for identified impacts. Impacts that have been assessed as not being significant are summarised in Table 17 and are not discussed further unless otherwise indicated.

Table 17 –Impacts not considered significant

Environment or social topic	Potential impact	Summary of assessment findings
Groundwater quality	Exposed tailings minerals to oxidising conditions and residual acids from petalite processing may potentially result in contamination to groundwater.	Based on the specialist assumptions and subsequent results from the contamination plume model, the impact from disposing of the tailings on the WRD has been assessed as negligible (Digby Wells, 2022) (Appendix F). A per the specialist findings groundwater quality in the project area is not expected to be negatively influenced during the Stage II operations. It is important to note that once the flotation circuit is ready to be included in the bulk sample, sorting, and testing facility the contamination plume model must be re-ran

Environment or social topic	Potential impact	Summary of assessment findings
		with new input parameters and impacts reassessed. Prior to a flotation circuit being consider by the proponent an amendment to the overall ESIA for its inclusion must be completed. This must then be submitted to the competent authority and MEFT for a record of decision.
Noise and vibrations	Potential increased noise impacts to neighbours	The potential for the mine to generate noise adversely impacting neighbours is unlikely given the distance from the operations to the nearest noise-sensitive receptor (+1km away) and the natural buffer effect of the sound attenuation features surrounding the active mine area, both natural and anthropogenic. The receptors are there as a product of historical mine developments therefore projected noise levels are not considered to significant alter the baseline and as such impacts not considered significant.
	Potential for ground vibrations from blasting activities on the surface	Vibrations from mining are variable, depending on the blast size, location within the site (depth), and blasting and mining methods. With mining there is the potential for vibration to follow fault lines and sometimes vibrations can be felt some distance away from the operation. The site will monitor vibrations and ensure vibrations are below allowable limits. Blast vibration assessment (Appendix D).
Avifauna	Bird habitat alteration or destruction	Although general disturbances could affect bird species of concern – i.e. species classified as endangered (violet wood-hoopoe, Ludwig's bustard, white-backed vulture, tawny eagle, booted eagle, martial eagle, secretary bird, black stork), vulnerable (lappet-faced vulture) and near threatened (Rűppel's parrot, kori bustard, Cape eagle owl, Verreaux's eagle, peregrine falcon) – birds are considered

Environment or social topic	Potential impact	Summary of assessment findings
		mobile and not limited to the project area. Their habitat is not present in the project area as the site is located within the current mining footprint. (Cunningham, 2022) Appendix G.
Dust emissions from current operations	Suspended dust plumes over the mine area, NamClay, Metal Mills, Uis, Tatamutsi Township areas and motorists driving on the C36 and C35 roads during construction and operation	Potential sensitive receptors are located northeast (~1.7 km) and northwest (~1.9 km) of the ML and not within the prevailing wind field (Airshed 2022). Therefore, it is not expected that dust plumes generated from construction and operation activities will cover the airspace over these receptors. Practical mitigation measures to ensure effective dust management is in place over the project area, and must be maintained.
Dust emissions from bulk sampling, sorting and testing facility	Suspended dust plumes over the project area during construction and operation stages	Due to the intermittent nature of construction operations, construction impacts are expected to have a small but potentially significant impact at the nearest AQSRs depending on the level of activity. With mitigation measures in place these impacts are expected to have minor significance. For both the Uis baseline and project scenarios, the significance is expected to be minor with and without mitigation in place during the operational stage (Airshed 2022)
Flood events	Potential destruction of mine and surrounding infrastructure	The results of the flood determination assessment indicate that the modelled floods for the 1:50-year and 1:100-year flood events will not inundate any mining area or surrounding infrastructure (Digby Wells, 2022), therefore this impact is considered non-significant.

Environment or social topic	Potential impact	Summary of assessment findings
Traffic volume to road capacity allowance and quality of road	Traffic congestion and road surface deterioration on the C36	The traffic impact assessment conducted by ITS global concluded that the C36 road operates at a very low capacity even with the addition of future vehicles from mine operations. The study showed that only 5% of its capacity will be utilised by this project, therefore the significance of this impact is considered very low and not assessed further (ITS, 2022) – Appendix K.
Archaeology and cultural heritage	Potential impact to known and unknown archaeological and heritage significant sites.	The proposed project activities will have no influence on known heritage sites within ML134 therefore no further assessment is required.
Climate change – adaptation	The potential for climate change to impact the proposed project, for example, extreme fire, heat or (extreme) storm events	The proposed Project will not be significantly impacted by the impacts of climate change as the design has considered measures in the event of increasing temperatures, emergency response plans will be in place in the event of a fire, and sufficient dewatering systems will be in place for managing potential water inflows into the mine workings. This impact should be reassessed once the final plant and design is complete.
Climate change – cause / contribute to	The proposed project contributes to climate change through the discharge of greenhouse gas emissions	The proposed project will generate greenhouse gases and therefore emissions however the emissions from the mining and processing operations are expected to be low due to its small production volume and footprint. The Equator Principles carbon dioxide equivalent (CO_2e) trigger limit of 100,000 tonnes CO_2e / year is one that medium scale mines could reach. At and beyond the trigger, a thorough climate change assessment is typically required by lenders and investors.

Environment or social topic	Potential impact	Summary of assessment findings
		The emissions calculated for UTMC included in a high-level estimate conducted by Promethium Carbon in 2021 relate to the combustion of diesel, explosive use, and consumption of electricity. The emissions from the diesel and explosive use have been categorised under Scope 1 emissions while those associated with the consumption of electricity have been categorised under Scope 2 emissions. The appropriate emission factors have been used in calculating these emissions, with the Scope 2 emission factor based on the Southern African Power Pool factor. The activity data used for the calculations are based on the information provided by Environmental Compliance Consultancy. This data consisted of invoices for diesel, explosives and electricity for a period spreading 2020 and 2021. The consumption figures were extracted from these invoices and annualised to obtain an average annual consumption. This average was multiplied by the emission factor to obtain the emissions. The estimated Scope 1 and 2 emissions from the UTMC mine amounts to 8 622 tCO_2e per year which falls below the threshold of 100 000 tCO_2e. UTMC has commissioned a climate change risk assessment of their current and future operations to better understand their operational impact on climate change to prepare for and drive future business strategy.

7.2 Socio economic environment: economic impacts

Impacts associated with the continued operation of the mine have been identified and have undergone the assessment process to derive the significance value of each impact. The impacts are classified into economic and social influences and assessed separately. The sensitivity of the economy is considered medium, as economic development is an important regional issue, albeit with limited progress within the district to date.

With the expected overall production output ranging from 80 to 120 tph of ore from the mine, it is anticipated that internal revenue generation will also increase in the form of payments received for mineral products sold worldwide. The company will continue to pay taxes, levies, and royalty payments to the government. The mine's capital expenditure and operational expenditure will also be channelled into the local, regional, and national spheres where feasible, thereby contributing directly and indirectly to the micro and macro-economies.

The term socio economic impact assessment embraces both social impacts and economic impacts. Economic impacts include issues such as employment, changes in economic activity such as mining and tourism, and increased expenditure. The significant economic impacts or impacts that have specific interest to the community and stakeholders, before mitigation, are summarised in Figure 57 for illustrative purposes only. Details related to each specific impact is discussed further in this Section.

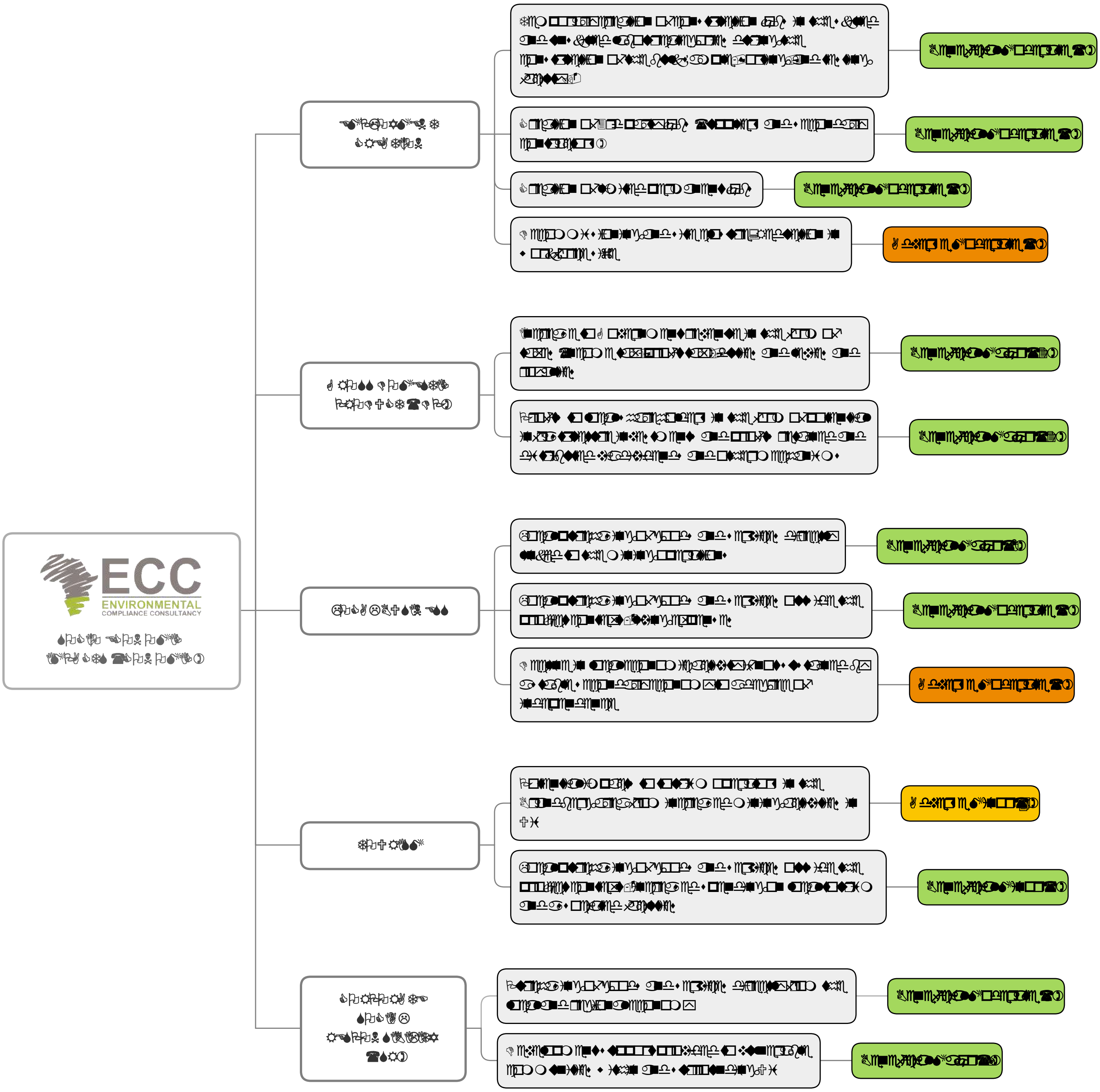

Figure 57 – Economic impacts

7.2.1 EMPLOYMENT CREATION

While Namibia generally has a high unemployment rate, the Erongo Region stands out with a below-average rate of 30% due to its affluent status. One measure of affluence is the per capita income of residents in each region, and the Erongo Region has the second-highest per capita income at N$16,819 per annum.

Mining in the Erongo Region makes a significant contribution to employment, surpassing all other sectors, with a 14% contribution to the national GDP. The populations of the Erongo and Khomas regions are projected to experience the most growth due to an upward urbanisation trend, with over a third of Namibia's population expected to reside in these two regions, according to the Namibia Statistics Agency (2011). The value and sensitivity of employment in these regions are considered high, as it is crucial to the country's overall development, regardless of project-specific quantities. Impacts on employment are detailed below and in Table 18.

7.2.1.1 DIRECT EMPLOYMENT IMPACTS – CONSTRUCTION

During the construction phase of the bulk sample, sorting and testing facility, a limited number of semi-skilled and unskilled labour jobs will be generated to support the construction activities. Additionally, the specialised services of a main contractor will be employed to oversee the construction program. This phase of the project is expected to last approximately six months.

7.2.1.2 DIRECT EMPLOYMENT IMPACTS – OPERATIONS

The operational phase of the Stage II expansion project's bulk sample, sorting and testing facility is expected to generate approximately 15 jobs. As a result, the magnitude of change during operations is considered moderate, given the duration and frequency of spending within the local economies, resulting in medium-term impacts and a moderate beneficial impact on the community and economy.

7.2.1.3 INDIRECT EMPLOYMENT IMPACTS

The UTM Stage II expansion project, encompassing the construction, operation, and decommissioning phases, is expected to create indirect employment opportunities throughout its Life of Mine (LOM). The engagement of various service providers will result in increased indirect employment opportunities for locals and individuals in the wider region beyond the district level.

As part of the project, an external transport company will be contracted to transport raw materials from outside the mining licence (ML) to the bulk sample sorting and testing facility on an intermittent basis throughout the month. Preliminary estimates suggest that this may involve up to 100 trucks.

7.2.1.4 Employment during the decommissioning and closure stage

In the event that an extension of the Life of Mine (LoM) for the UTM Stage II expansion project is not possible, the mine will enter the decommissioning and closure stages. As part of this process, downsizing of the workforce is anticipated, with non-essential and production personnel being made redundant sequentially. The loss of employment is considered highly sensitive to the affected individuals, and therefore the significance of this impact is deemed moderate, as it would not prevent them from seeking and obtaining future employment.

The impact on the local and regional economy is also considered of moderate significance, with a sensitivity rating of medium expected. The impact is expected to be long-term, with limited opportunities to maintain the pre-impact status unless a similar project is brought to the area as a replacement.

Table 18 – Impact assessment on employment and job creation

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Construction of the Bulk sample, sorting, and testing facility	Community	Creation of temporary construction jobs in the skilled and unskilled labour categories	Beneficial Direct Regional Temporary Reversible	High	Minor	Beneficial Moderate (6)
Downstream job creation	Community Local economy	Creation of 3rd party jobs (suppliers and secondary contractors)	Beneficial Indirect Regional Medium Term Reversible	High	Moderate	Beneficial Moderate (6)
Operations of the proposed project	Community Job seekers Local economy	Creation of limited permanent jobs	Beneficial Direct Regional Medium Term Reversible	High	Moderate	Beneficial Moderate (6)
Decommissioning and closure	Community	Reduction in workforce size.	Adverse Direct Regional Permanent Irreversible	High	Moderate	Adverse Moderate (6)

7.2.2 IMPACTS TO GROSS DOMESTIC PRODUCT (GDP)

Revenue for the Namibian government consists of income tax, profit tax, value added tax, withholding tax, duties and levies, royalties (in the case of mining projects) and other taxes. Profits to local shareholders are also expected in the form of potential infrastructure developments and profits retained and distributed via dividends and other mechanisms. Revenue and profits are expected to improve the local economy and the contribute towards the mining sectors positive impact on the Namibian gross domestic product (GDP).

It is expected that in the first year (FY2024) revenue will amount to USD 26.8 million p.a. (~NAD 484,000,000) and by the second year (FY2025) and beyond to USD 28.7 million p.a. (~NAD 518,000,000). However, the financial model is continuously changing and will be finalised by the Proponent when operations ramp up. Currently mining contributes to 10% of the GDP in Namibia. The impacts to the GDP are further described in the section below and Table 19.

7.3 IMPACTS ON REVENUE FOR GOVERNMENT

All revenue requirements are legally required to be paid by mining companies during operations and therefore the Proponent will contribute to the GDP in this manner and the probability is definite. Sales will be in US dollars and therefore in-turn this will be a positive contribution by bringing is USD into the country and will assist with balancing out of payments.

The impact is expected to be direct, long term for the duration of mining activities (LOM 2039) and irreversible. Monies are paid to local business, regional and national government institutes. The value of sensitivity is high as the revenue income will contribute positively to the overall countries GDP. The magnitude of change is rated as high/major due to the contributions of this new sector within the mining industry. The significance of the impact is expected to be beneficial major.

7.3.1 IMPACTS ON PROFIT TO LOCAL SHAREHOLDERS

It is expected that the Proponent will contribute to profits of local shareholders by infrastructure development and investment, and profits retained and distributed through dividends or other financial mechanisms. This in turn contributes to the local economy. The impact therefore may be direct, long term for the duration of mining activities (LOM 2039) and irreversible. The probability is rated as definite. The value of sensitivity if rated as high due to the positive influence on local livelihoods. The magnitude of change is rated as high/major due to the positive impacts on the local economy. The significance of the impacts if therefore rated as beneficial major.

Table 19 – Impact assessment for gross domestic product (GDP)

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Operations	Nationals and local government	Government revenue in the form of taxes (income tax, profit tax, value added tax), duties and levies and royalties.	Beneficial Direct National Long term Irreversible	High	High/Major	Beneficial Major (12)
Operations	Local shareholder and local economy	Profits to local shareholders in the form of potential infrastructure investments and profits retained and distributed via dividends and other mechanisms.	Beneficial Direct National Long term Irreversible	High	High/Major	Beneficial Major (12)

7.3.2 IMPACTS TO TOURISM

Tourism is an important industry in the Erongo Region, particularly in the coastal towns of Swakopmund and Walvis Bay. Uis, a town that serves as a link between the coastal towns and Namibia's highest mountain, the Brandberg, is also a popular tourist destination. Uis is the gateway to Damaraland an area well known for its famous desert-adapted lion and elephant populations. Uis is known for the remnants of the world's largest tin mine and the infamous "white" dune, which is a popular location for tourists to enjoy sunset views of the Brandberg.

The changes associated with Stage II of the project are not expected to have a negative impact on tourism, as the operational mining in Uis is already active and the town's existence is historically linked to mining. The mining operations are not in close proximity to the tourist attractions, except for the "white dune," which is a historic mining waste stockpile. The impacts on tourism as a result of the proposed project are detailed in the section below and Table 20.

There is a high probability that the additional staff and revenue generated from the mining operation will increase local spending in establishments that also cater to the tourism markets. The staff supporting the project will require accommodation and may use these tourism establishments for board and lodging. This has been welcomed by the Uis community in the past, as it supported local businesses during the global COVID-19 pandemic when the tourism market was shut down.

Therefore, this impact will have an indirect and long-term effect on the tourism industry for the duration of the project, and partly irreversible. The spending is expected to not only occur within Uis but also in other towns in the region, such as Swakopmund and Walvis Bay. The tourism market in Uis is considered to have low sensitivity, as the additional income provided to local businesses and the economy from the operational staff will occur on an ad hoc basis. The magnitude of change is considered moderate, as spending on the tourism industry is expected to take place regularly. The probability is considered definite, as spending will occur.
Tourist perception of mining can vary depending on various factors such as the location, type of mining operation, and the impact of mining on the local environment and community. Some tourists may view mining as a negative impact on the natural and cultural heritage of a destination, as it may alter landscapes, disrupt ecosystems, and potentially impact local communities and their way of life. They may be concerned about the environmental and social sustainability of mining activities and may perceive it as a threat to the authenticity and integrity of a destination. On the other hand, some tourists may be interested in the historical, cultural, and economic significance of mining, and may view it as a unique aspect of a destination's heritage and identity. They may be interested in learning about the history, technology, and processes of mining, and may see it as a source of local livelihoods and economic development. Overall, tourist perception of mining can be complex, and it is important for the proponent and stakeholders to carefully manage and

communicate the impacts of mining to ensure a positive perception among tourists, especially in Uis where mining plays a pivotal role in local economic and social welfare.

The overall significance of the impact is expected to be minor, but beneficial. No mitigation measures are required to be implemented.

Table 20 – Impact assessment on tourism

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Operations	Local tourism and local economy	Purchasing of goods and services outside the project context such as spending on local tourism and establishments	Beneficial Indirect Regional Long term Partly reversible	Low	Moderate	Beneficial Minor (3)
Operations	Local tourist perception of mining	Negative tourist perception of mining and impacts on the environment	Negative Indirect Regional Long term Partly reversable	Medium	Low	Adverse Minor (4)

7.3.3 IMPACTS TO LOCAL BUSINESSES

The operational mining activities will require support by local business. This will be in the form of direct and indirect impacts on the local economy. The impacts on local business are further discussed in the Sections below and Table 21.

7.3.3.1 DIRECT IMPACTS – LOCAL PURCHASING OF GOODS AND SERVICES DIRECTLY LINKED TO THE MINING OPERATIONS

Mining operations require purchasing goods and services to sustain the operation and support its staff. In 2021, Uis generated over NAD 141 million in local procurement, as reported by the Chamber of Mines. This significant contribution to local procurement provides long-term benefits not only for Uis but also for the wider region and Namibia as a whole. This injection of local procurement is considered irreversible, as it will continue for the duration of the project (LOM 2039). It will directly support local businesses and the economy, and may even extend to a national scale if goods or services are not available locally and need to be sourced from other areas like

Windhoek. The sensitivity of this impact is expected to be medium, and the magnitude of change is expected to be high, as businesses will be engaged and supported throughout the project's duration. The overall significance of this impact is expected to be major and beneficial. No mitigation measures are required to be implemented.

7.3.3.2 DIRECT IMPACTS – PURCHASING OF GOODS AND SERVICES OUTSIDE THE PROJECT CONTEXT SUCH AS LIVING EXPENSES

A large majority of the mining staff reside in Uis and contribute to the local economy by purchasing goods, services, and accommodation for themselves and their families. This indirect impact is expected to be long-term for the duration of the project, but partially reversible. Local businesses could benefit at a regional scale, as spending may occur outside the immediate scope of Uis. The probability of this impact occurring is considered highly probable. The sensitivity of this impact is expected to be low, and the magnitude of change moderate, as local spending within the local economy is anticipated. Overall, the significance of this impact is expected to be beneficial but minor. No mitigation measures are required to be implemented.

Table 21 – Impact assessment for direct and indirect spending on local business

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Operations	Local businesses Sub-contractors	Local purchasing of goods and services directly linked to the mining operations	Beneficial Direct National Long term Partly reversible	Medium	High/major	Beneficial Major (8)
Operations	Local businesses	Local purchasing of goods and services outside the project context - living expenses	Beneficial Indirect Regional Long term Partly reversible	Low	Moderate	Beneficial minor (3)
Decommissioning and closure	Local and regional economies	Decline in local economic activity if not sustained by a stable	Adverse Direct Regional Long term Partly reversible	Medium	High	Adverse Moderate (6)

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
		secondary economy				

7.3.4 CORPORATE BASED INVESTMENTS

UTMC has been actively engaged in the Uis community since the start of its operations in 2019, implementing inclusive and supportive approaches to contribute to the economic and social wellbeing of the local community (ESG, 2022). The Proponent has been proactive in supporting local small and medium-sized businesses by providing procurement opportunities, as well as sponsoring local sports clubs, the traditional authority, and wildlife conservation initiatives in the greater area. The magnitude of change to the receiving social environment, as indicated in Table 22, is considered high, given the economic vulnerability of the receptors in the status quo. As a result, it is expected that there will be an increase in attribute quality, which will have a positive impact on the local community.

Table 22 – Impact assessment for corporate social responsibility

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Direct Procurement	Local economy	Purchasing of goods and services directly from the local and regional economy on an assumed equal basis	Beneficial Direct Local Medium Term Reversible	Medium	Moderate	Beneficial Moderate (6)
Corporate social responsibility	Community	Development support provided to vulnerable communities	Beneficial Indirect Regional Medium Term Partly reversible	High	High	Beneficial Major (9)

7.4 SOCIO ECONOMIC ENVIRONMENT: SOCIAL IMPACTS

A social impact assessment is an essential tool for understanding the potential impacts of a mining project on the surrounding communities and stakeholders. It aims to identify potential social risks and benefits associated with the project and suggests measures to mitigate any adverse effects. This report presents the keys social impact for the proposed changes at Uis Tin Mine. The mine is located in a region with a significant population that relies on the natural resources (minerals and mineral extraction) for their livelihoods. The purpose of this assessment is to evaluate the potential social impacts of the proposed mine changes on the surrounding communities and stakeholders.

This section of the report analyses the potential impacts of mining activities on various social aspects, including traffic, nuisance air and noise impacts, employment, health, education, culture, and community development. The assessment will also identify potential risks and benefits associated with the mine and suggest measures to mitigate any adverse effects and enhance the positive impacts. The assessment will provide valuable information for decision-making and ensure that the mine operates in a socially responsible manner, minimising its impact on the surrounding communities and stakeholders while maximising the benefits of the project. The significant social impacts or impacts that have specific interest to the community and stakeholders, before mitigation, are summarised in Figure 58 for illustrative purposes only. Details related to each specific impact is discussed further in this section.

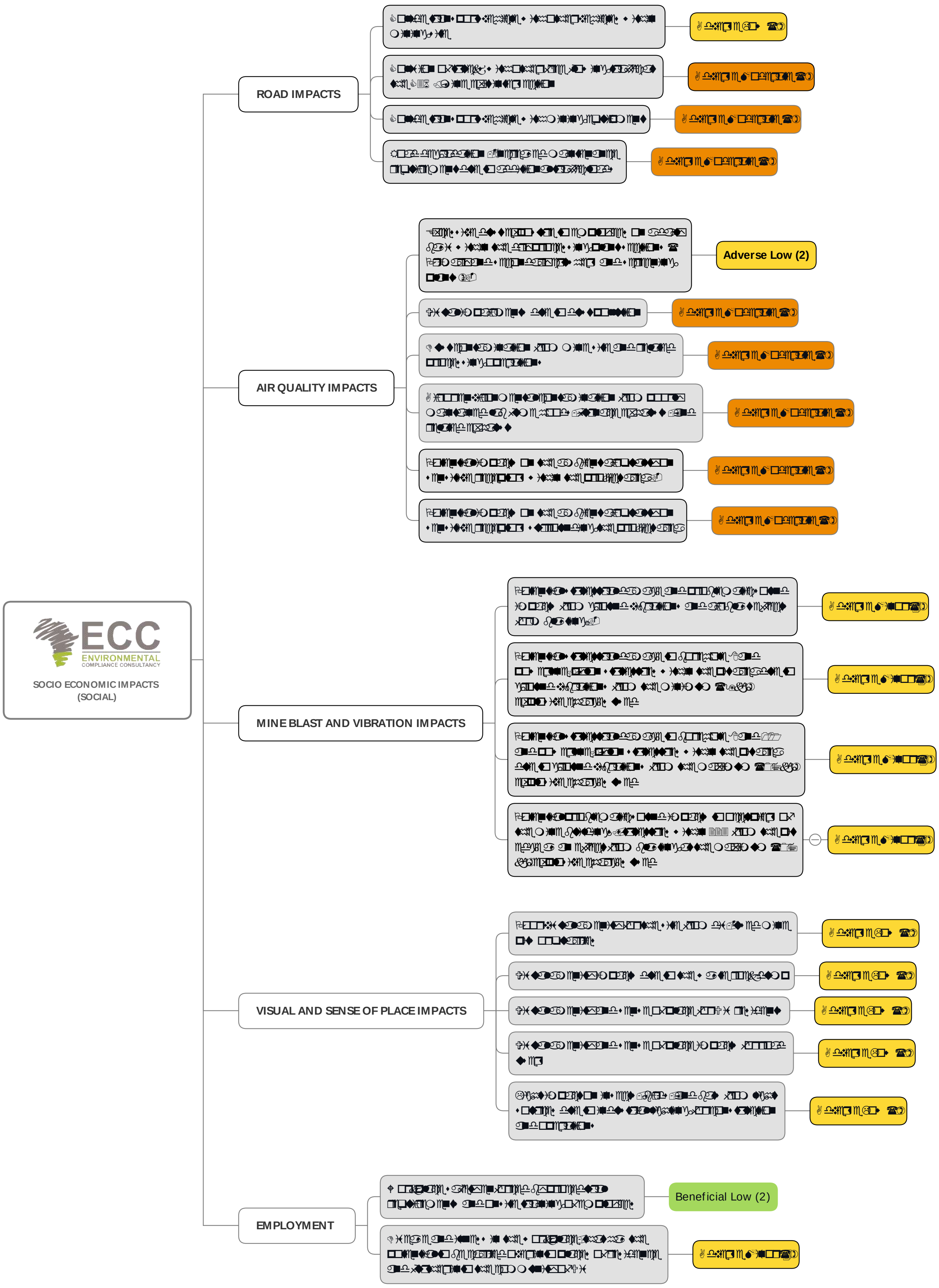

Figure 58 – Social impacts

7.5 TRAFFIC AND ROAD SAFETY

Traffic safety: Mine entrance/exit - The area of concern is located at the mine access intersection leading off from the C36 towards the boom-control access gate of the mine. The current speed limit along the C36 roadway is 100 km/hr. However, the required shoulder sight distance (SSD) for this operational speed is 200 meters for cars and 300 meters for a single unit truck. The available SSD at this exit is approximately 240 meters, which is sufficient for cars, but insufficient for trucks (ITS, 2022).

The pre-mitigation impact significance of potential collisions involving trucks at this intersection is considered moderate within the social environment once it occurs as set out in Table 23.

Table 23 - Expected impacts related to traffic conditions at mine entry / exit point along the C36

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Access and roads	Community	Collision of trucks with other free flowing traffic past the C36 / mine entry intersection.	Adverse Direct Local Medium Term Reversible	Medium	High	Moderate (6)

The significance of the impact on the safety of drivers of vehicles and trucks and the public along the C 36 / mine entrance intersection can be lowered to a minor ranking with the effective implementation of the recommended mitigation measures by the traffic assessment specialist as shown in Table 24. Mitigation measures include installing street lighting at this intersection to promote high visibility during night-time hours and reduce the risk of collisions between cars and trucks from the mine or otherwise privately owned. it is further recommended that the speed limit along the C36 should be reduced to 80 km/hr for approximately one km on either side of the mine intersection. This will increase the SSD along this section to a sufficient distance. A further recommendation Is for the proponent to resurface the road for that 1km distance on either side of the mine entrance intersection.

Table 24 - Expected impact related to traffic conditions post mitigation

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Access and roads	Community	Collision of trucks with other free flowing traffic	Adverse Direct Local	Low	Minor	Minor (3)

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
		past the C36 / mine entry intersection.	Short Term Reversible			

7.6 Air Quality Impacts

7.6.1 Exposure to Dust

The main pollutant of concern associated with the mining operations is particulates. Particulates are divided into different particle size categories with total suspended particulates (TSP) associated with nuisance impacts and the finer fractions of PM10 (particulates with a diameter less than 10 µm) and PM2.5 (diameter less than 2.5 µm) linked with potential health impacts. Gaseous pollutants (such as sulphur dioxide, oxides of nitrogen, carbon monoxide etc.) will derive from vehicle exhausts and possibly from the mineral processing operations but are regarded as negligible in comparison to particulate emission.

The potential expected sources of dust particulate matter resulting from the operational activities include but are not limited to construction activities on settling ponds, the return water pond (RWP); mineral material handling and processing; and mining activities within V1 and V2 open pits) such as drilling, blasting, and hauling.

Analysis of depositional dust volumes in AQ02 and AQ09 which are the closest stations to the processing area showed thresholds for residential and industrial exposure standards are not exceeded for the last twelve months ending July 2022. This can be attributed to dust suppression methods effectively employed at the comminution areas. Table 25 presents the dust exposure thresholds for residential and industrial areas. From the laboratory results obtained these thresholds are well below half the standard for industrial areas and therefore pose no threat to employee health surrounding these stations. However, fugitive emissions at the source (i.e., comminution areas (primary and secondary crushers and screens), and open conveyor systems) are concentrated and do require employees to always wear the correct PPE.

Two operational scenarios were assessed, namely the incremental and cumulative Petalite Beneficiation Plant scenarios, each with an unmitigated and mitigated sub-scenario.

- Emissions for the plant were quantified based on provided information on processing rates and plant layout. o Drying and Classifying is the main source of PM10 and PM2.5 emissions from this process, followed by unpaved roads for PM10 and crushing and screening for PM2.5. The main source of TSP emissions is crushing and screening, followed by unpaved roads.

- Dispersion modelling results for the incremental plant Simulated values for PM10, PM2.5 and maximum daily dustfall rates at AQSRs are negligibly small.
- PM10 and PM 2.5 daily GLCs, for unmitigated activities, result in exceedances of the 24-hour air quality objective (AQO) over a maximum distance of ~90 m from on-site activities.
- The footprint of exceedance of maximum daily dustfall rates exceed the AQO within 125 m from the facility's activities.

Table 25 - Dust exposure thresholds for residential and industrial areas

Level	Dust fall rate (mg/m2/day)	Averaging period	Permitted frequency of exceeding dust fall rate
Action Residential	D < 600	30 days	Three within any year, no two sequential months
Action Industrial	D < 1200	30 days	Three within any year, not sequential months
Alert Threshold	D < 2400	30 days	None. First incidence of dust fall rate exceeded requires remediation and compulsory report to relevant authorities

Airshed (2022) determined that due to the intermittent nature of construction operations, construction impacts are expected to have a small but potentially harmful impact at the nearest AQSRs depending on the level of activity. With mitigation measures in place these impacts are expected to have a minor significance and not assessed further.

For receptors closest to the sources of dust, and with the use of relevant PPE, dust suppressants to minimize dust at the source, the impact is reduced to minor from moderate, considering the moderate to a high magnitude of the potential impact, its certainty, and moderate sensitivity of the receptor. The scale of the impact associated with the potential deterioration in air quality from particulate matter is considered direct and limited to onsite areas, the nature of the potential impact is considered medium-term and reversible - when operations cease the potential impact also ceases, therefore the magnitude of change is considered minor to moderate as shown in Table 26.

Table 26 - Impacts on employees during operations from processing activities

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Existing operations	Environment – people	Dust contamination from mine site and related existing processing operations	Adverse Direct Reversible Medium term Onsite Almost certain	Medium	Moderate	Adverse Moderate (6)
Construction of the bulk sampling, sorting and testing facility	Environment – people	Dust contamination from the construction of the bulk sample, sorting and testing facility	Adverse Direct Reversible Medium term Onsite Almost certain	Medium	Moderate	Adverse Moderate (6)

7.7 GROUND VIBRATION AND AIR BLAST IMPACTS

The potential impacts of ground vibration from blasting activities on nearby receptors (communities included as set out in Appendix D) were assessed. The level of impact was determined by the explosive charges used by the mine (minimum charge of 69 kg and the maximum charge of 207 kg). The impact to infrastructure is contained onsite with a long-term duration as blasting is an integral part of the mining process.

Based on the simulated results from the ground vibration evaluation for the minimum charge, boreholes 8 and 11, and the power line/pylon structures within the pit area may be at risk of damage. All other structures beyond this point presented an acceptable level of tolerance against ground vibrations. The results from the simulated maximum charge impacts on structures within the project area indicated that boreholes 8 and 11 as well as the power line/pylon structure within the mine pit area to be at risk potentially.

The nearest public houses are located 1070 m from the pit boundary. Ground vibration levels predicted at these buildings where people may be present is 0.9 mm/s for the maximum charge. In view of this no specific mitigations will be required (Zeeman, 2022).

The magnitude of change as a result of ground vibration influences on mine infrastructure, including boreholes are deemed as minor because of the expected minor loss of, or alteration to, one (or maybe more) key characteristic of the boreholes and the power line/ pylon structure.

Sound pressure levels in excess of the maximum threshold of sound exposure (134 dBs) are expected to occur within a distance of 223 m from the open pit. Mine buildings (office) are found within this zone and the calculated sound pressure level of 134.7 dBs may present a problematic influence on the occupiers of the office buildings and surrounding infrastructure areas within the distance limit applied. The magnitude of change on the receptors is deemed as medium due to the fact that exposure duration is intermittent and sound levels are not exceeded by a big margin over the threshold. However, the duration of the impact is long-term and warrants some attenuation measures to be considered see Table 27. With proper mitigation applied it is anticipated that the significance of these impacts can be adjusted to low (2).

Table 27 - Ground vibration and air blast impacts

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Blasting (open pit mining)	Mine infrastructure	Potential structural damage to Borehole 8 and power line/pylon structures within the pit area due to ground vibrations from the minimum (69kg) explosive charges used	Adverse Direct Reversible Long-term Onsite Possible	Medium	Minor	Minor (4)
Blasting (open pit mining)	Mine infrastructure	Potential structural damage to Borehole 8 and 11 and power line/pylon structures within the pit area due to ground vibrations from the maximum (207 kg) explosive charges used	Adverse Direct Reversible Long-term Onsite Possible	Medium	Minor	Minor (4)
Blasting (open pit mining)	Occupiers of mine buildings / structures	Potential problematic sound impacts to occupiers of the mine buildings/structures within 223 m from the pit edge as an effect from blasting at the maximum (207 kg) explosive charges used causing sound levels more than 134dBs.	Adverse Direct Reversible Long-term Onsite Possible	Medium	Minor	Minor (4)
Fly rock created from	Structures / POI within	Potential problematic fly	Adverse Direct	Low	Low	Low (1)

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
incorrect blasting (i.e., stemming height)	500m from blast zone	rock induced damage to structures within a 500m radius around the blast zone aka. the safe zone, from incorrect blasting activities	reversible Temporary Onsite Improbable			

7.7.1 GROUND VIBRATION AND AIR BLAST IMPACTS MITIGATION MEASURES.

Mitigation of ground vibration effects can be done by applying the following methods:

- Do blast design that considers the actual blasting, and the ground vibration levels to be adhered too.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.
- Relocate the POI / acquire the POI of concern – mine owned.

The blasting method that exerts the least amount of environmental and social influence on Project receptors as well as to produce smaller rock fragments was recommended through specialist input. In most cases basic planned design does not need to change but timing can be adjusted as well as using electronic timing to reduce the charge mass per delay. This must be confirmed with monitoring of ground vibration at the POI.

A monitoring programme for recording blasting operations is recommended by the specialist and the following elements should be part of such a monitoring programme:

- Ground vibration and air blast results;
- Blast Information summary;
- Meteorological information at the time of the blast;
- Video Recording of the blast;
- Fly rock observations.

Most of the above aspects do not require specific locations of monitoring. Ground vibration and air blast monitoring requires identified locations for monitoring. Monitoring of ground vibration and air blast is done to ensure that the generated levels of ground vibration and air blast comply with recommendations.

Proposed positions were selected to indicate the nearest points of interest at which levels of ground vibration and air blast should be monitored for compliance within the accepted norms and standards as proposed in the specialist's report. The monitoring of ground vibration will also qualify the expected ground vibration and air blast levels and assist in mitigating these aspects properly. This will also contribute to proper relationships with the neighbours.

Three monitoring points were identified as possible locations that will need to be considered. Monitoring positions are indicated in Figure 59 lists the positions with coordinates. These points will need to be re-defined after the first blasts are done and the monitoring programme defined.

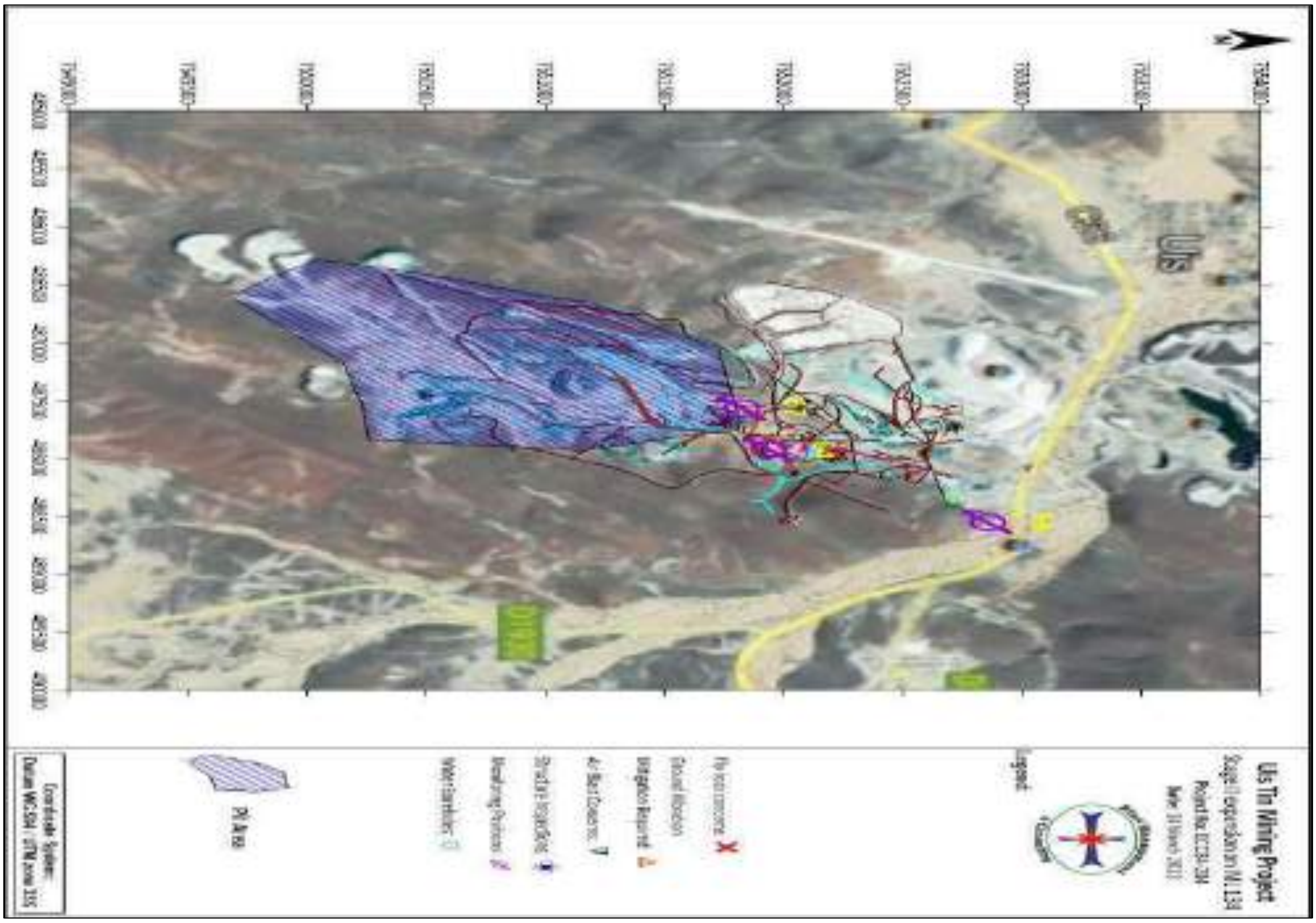

Figure 59 - Recommended monitoring positions (60, 64, 67) (Zeeman, 2022)

7.8 VISUAL AND SENSE OF PLACE IMPACTS

The visual and sense of place impact assessment evaluated the potential impacts of mining activities on the surrounding communities' visual aesthetics and sense of place. The following is a summary of the potential impacts identified and measures to mitigate them.

Landscape alteration: Mining activities alter the landscape which can significantly impact the visual aesthetics of the surrounding area. This is mitigated for the project as the site is located within an area outside of the standard viewshed for residents as described in section 5.24 the site is surrounded by historic mine waste rock dumps and is shielded by mountains.

Noise: Noise generated from mining activities can result in nuisance noise impacts to residents leading to a loss of sense of place and impact the residents’ quality of life. Although these project changes do not alter the current baseline noise levels, this should be monitored by physical measurements and recording of public concerns or complaints. If the project does start receiving noise complaints, the project should implement a noise management plan, such as the use of barriers, redirecting mining activities at sensitive times such as night, or implementing strict noise limits if required.

Visual pollution: Mining activities can generate visual pollution, including dust, light and emissions. These can impact the visual aesthetics of the surrounding area, leading to a loss of sense of place and impact on the quality of life of residents. This can be mitigated by implementing measures to reduce visual pollution, such as using water sprays to control dust, implementing emission controls on mining equipment, using downward pointing lights and using natural barriers to screen mining activities.

Overall, the visual and sense of place impacts of a new mine can be significant. These project changes, however, are not deemed significant. By addressing these impacts, the proponent can ensure that their operations are socially responsible and respectful of the surrounding communities and stakeholders, thus preserving the visual aesthetics and sense of place of the area.

7.9 BIOPHYSICAL ENVIRONMENT IMPACTS

A biophysical impact assessment is a critical component of any mining project as it aims to evaluate the potential physical and biological impacts of the project on the surrounding environment. This assessment provides valuable information that helps the reader and decision makers identify and mitigate potential risks and impacts associated with the project. This section presents the biophysical impact assessment for the proposed change to the Uis Tin mine.

As described in the baseline chapter, the mine is located in a region with diverse flora and fauna, and water resources, making it critical to assess the potential impact of mining activities on the biophysical environment. The purpose of this assessment is to evaluate the potential impacts of the proposed changes to the mine on the surrounding environment, including soil, water, air quality, vegetation, and wildlife. The section of the report analyses the potential impacts of mining activities on each of these components and suggest measures to mitigate any adverse effects. The assessment will provide valuable information for decision-making and will ensure that the mine operates in an environmentally responsible manner, minimising its impact on the biophysical environment.

The term biophysical impact assessment embraces the potential impacts on the biophysical environment including the abiotic and biotic environments. The significant biophysical impacts or impacts that have specific interest to the community and stakeholders, before mitigation, are summarised in Figure 60 for illustrative purposes only. Details related to each specific impact is discussed further in this section.

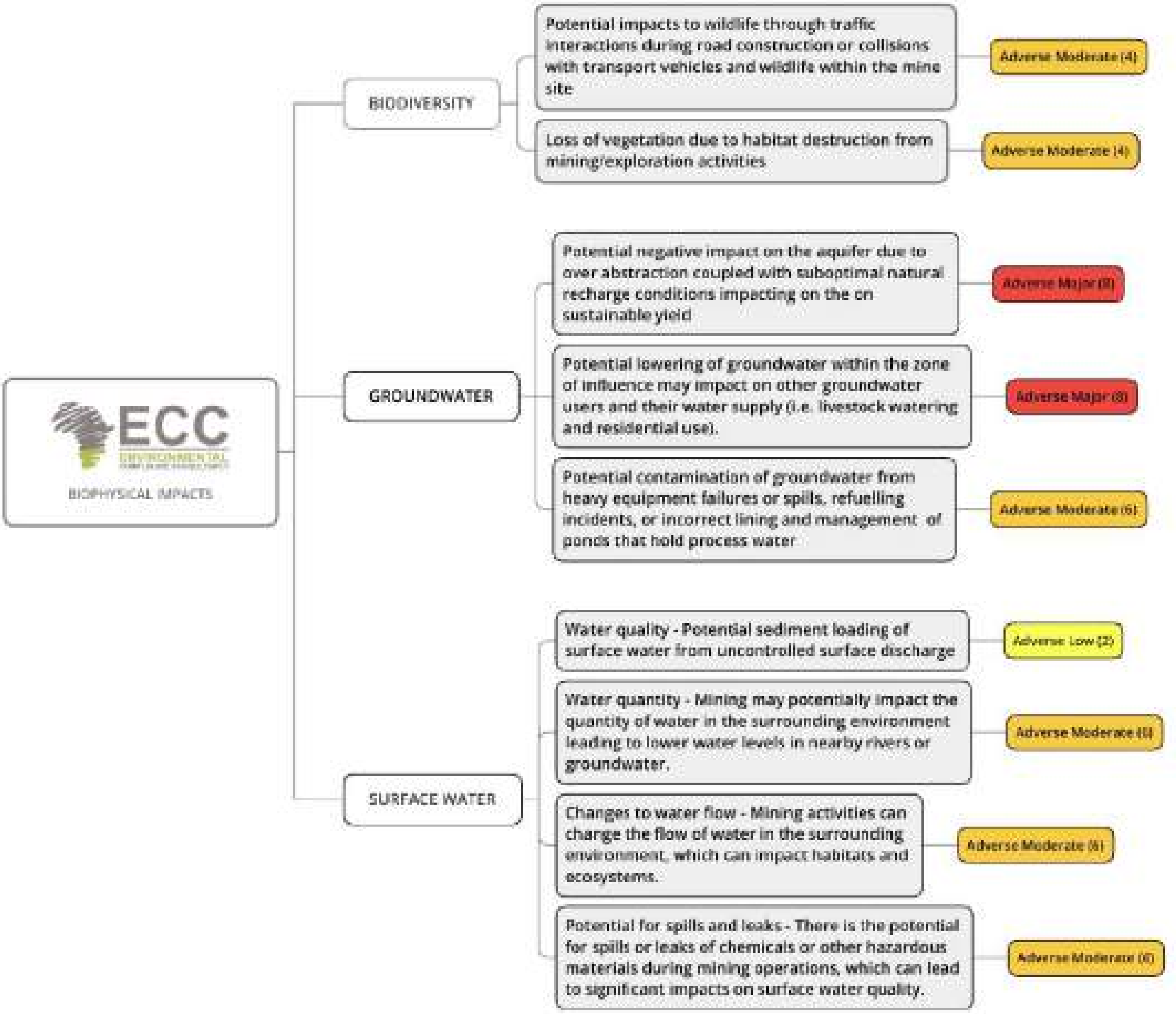

Figure 60 – Biophysical impacts

7.10 BIODIVERSITY IMPACTS

7.10.1 WILDLIFE COLLISIONS WITH MINE VEHICLES

The impact of fauna interactions with mining vehicles can have significant consequences on both the wildlife and the mining operations. Such interactions can lead to injury, death, or displacement of the animals, which can disrupt the ecosystem and affect biodiversity. Additionally, mining vehicles can suffer damage, which can result in downtime, delays, and increased costs for the mining operations.

The severity of the impact would be localised and limited to the extent of the mine operations see Table 28. It is possible that some species such as Kudus could be involved in such localised events, similarly to other parts of Namibia and road interactions. This impact wouldn't be unique to the site.

To mitigate the impact of fauna interactions with mining vehicles, it is important to implement effective management practices. This can include establishing exclusion zones or barriers around sensitive habitats, minimising vehicle movements during peak animal activity times, and implementing speed limits or other traffic control measures to reduce the risk of collisions.

Overall, the impact of fauna interactions with mining vehicles is minor as no areas of sensitive habitat has been identified that interacts with the mining traffic routes. Sensitive habitats i.e. drainage lines and rocky ridges are not used for transportation. This should be reviewed as transport routes change during operations to ensure the sustainability of both the mining operations and the surrounding ecosystem.

Table 28 - fauna impacts

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Continued mining and exploration activities within the mining areas	Fauna	Collisions with wildlife	Adverse Direct Partly reversible Long-term On-site Probable	High	Moderate	Minor (4) (with mitigation)

7.10.2 FLORA DISTURBANCES

Flora disturbance for the proposed mining/exploration activities would be localised to unique habitats (e.g. drainage lines, hills/ridges) with associated flora that would bear the brunt of this proposed development, but be limited in extent and only permanent at the actual mining site(s) and access routes and infrastructure sites.

As all development have potential negative environmental consequences, identifying the most important flora species including high risk habitats beforehand, coupled with environmentally acceptable mitigating factors, lessens the overall impact of such development. It is not expected that further mining/prospecting developments will adversely affect any unique flora in the ML 134 area, especially if the proposed recommendations (mitigation measures) are incorporated which are contained in the EMP (Cunningham, 2022).

Typically, one of the most significant impacts of mining on flora is habitat loss. Mining activities often involve clearing large areas of land, removing vegetation and disrupting soil ecosystems. This can lead to the loss of plant species, especially those that are endemic to the area or that have specific habitat requirements. As per Cunningham 2022 the site is already heavily disturbed and the potential risk for significant flora or habitat loss is unlikely as the site has undergone significant disturbance.

Mining activities can also cause soil erosion, which can further exacerbate the loss of plant life in the area. Soil erosion can lead to a loss of nutrients, compaction of the soil, and changes to the water regime, which can all have negative impacts on plant growth and survival. The soils within the site are heavily disturbed, however in new areas where mining hasn't occurred the proponent will ensure that clearing is kept to a minimum, and soil is stockpiled for future rehabilitation purposes. It is almost certain soil impacts will occur in areas where mining infrastructure will be located, the impact will be long term but localised, and partially reversable the significance of the impact is minor.

Mining activities can also increase the risk of invasive species entering the area. The disturbance caused by mining can create new niches for invasive species to establish themselves, which can displace native plant species and alter the ecological balance of the area. This would have a significant impact on the biodiversity in the area and has the ability to spread regionally, the impact would be partially reversable, long term and adverse see Table 29. The proponent will ensure all equipment is washed down prior to coming to site and that a weed and seed inspection is completed for each piece of equipment when it arrives at the mine site from another area.

Table 29 - Flora impacts

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Vegetation removal to clear areas for mining infrastructure	Flora	Loss of vegetation due to habitat destruction from mining/exploration activities	Adverse Direct Partly reversible Long-term On-site Probable	High	Moderate	Minor (4) (with mitigation)

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Removal of natural areas for mining infrastructure	Flora	Loss of habitat from mining/exploration activities	Adverse Direct Partly reversible Long-term On-site Probable	High	Moderate	Minor (4) (with mitigation)
Cleared areas expose soils and increase risk of soil erosion	Flora	Soil erosion from removal of vegetation	Adverse Direct Partly reversible Long-term On-site Probable	High	Moderate	Minor (4) (with mitigation)
Use of machinery for mining operations and introduction of invasive species	Flora	Loss of vegetation due to habitat destruction from mining/exploration activities	Adverse Direct Partly reversible Long-term On-site Probable	High	Moderate	Minor (4) (with mitigation)

7.11 Ground and Surface Water Impacts

7.11.1 Groundwater Impacts

The groundwater levels (post abstraction) in the area of the mine workings range from 20 - 35 meters below the surface (mbs). The project area is characterised by fractured igneous and metamorphic rock aquifers which are overlain by shallow alluvial aquifers in river channels and as surface cover in some areas (Digby Wells, 2022). The water supply boreholes have been drilled in the Uis River and an unnamed river tributary south of the mine, comprising the Uis and Southern wellfields (Digby Wells, 2022).

From the groundwater supply investigation report prepared by Digby Wells it is concluded that the aquifer can sustain a yield of 18.7 m3/hr over the 18-year life of mine for the Phase 1 Stage II expansion requirements. The mine requires a yield of 18m3/hr to sustain its operations over the 18-year life of mine, which equates to 127 440 m3 per year at a 20-hour per day pump rate and assuming both the Uis and Southern wellfields are utilised. Based on the simulation result from the numerical model the abstraction of water from the aquifer is sustainable. Should there be any significant increases in water demand from the aquifer the long-term sustainable yield needs to be re-calculated.

The expansion of the pilot processing plant to Phase 1 Stage II will increase production at the mine to ~100 tonnes of tin concentrate per month, which will increase the water demand of the plant to ~0.432 Ml/day (18 m3/hr). Water is currently sourced from water supply boreholes in the Uis River channel as well as contributions from water stored within the K5 pit and the investigation assessed whether the water supply boreholes can meet the increased demand for the planned 18-year Life of Mine of the Phase 1 Stage II expansion (Digby Wells, 2022). In addition, based on the numerical model simulations the water supply abstractions over the 18-year period will stress the aquifer due to the low recharge potential of the region.

The cumulative abstractions (from third party users) for the proposed 18-year Life of Mine will create a drawdown cone with a maximum extent of ~6.5 km and a drawdown of ~4.5 m. Including the third-party water supply for the duration of the Phase 1 Stage II life of mine provides a cumulative impact for the area as a worst-case scenario for Andrada. As the third-party abstractions are not anticipated to take place for the full duration of the Phase 1 Stage II life of mine, the extent of the drawdown cone and drawdown in the aquifer may be less than the predicted outcome in the hydrogeological report, which affords Andrada some flexibility to adjust to potential changes in user behaviour.

Table 30 shows the significance rating of the potential adverse water supply impacts before mitigation (pre-impact status). Table 31 shows the lowering of the significance rating after mitigation measures as described in 7.3.2 have been applied.

Table 30 - Water availability impacts

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Over-abstraction for mining and processing activities	Water (availability)	Negative impact on the sustainable yield of the aquifer due to over-abstraction coupled with sub-optimal natural recharge conditions	Adverse Direct Partly reversible Long-term Regional Probable	High	High	Adverse Major (8)
Groundwater cone of depression from potential	Water (availability)	Lowering of the groundwater within the zone of influence may impact on other	Adverse Direct Partly reversible Long term Regional	High	High	Adverse Major (8)

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
cumulative abstractions		groundwater users and their water supply (i.e., livestock watering and residential use).	Probable			
Potential large-scale hydrocarbon spills from machinery and equipment on site	Groundwater quality	Potential hydrocarbon contamination of groundwater from heavy equipment failures or spills, or incorrect servicing procedures	Adverse Direct Partly reversible Long term Regional Probable	Medium	High	Adverse Moderate (6)

7.11.2 WATER SUPPLY MITIGATION MEASURES

The following mitigation measures are recommended by the hydrogeological specialist to be put in place with regard to mitigating the impact of reduced water supply:

- Ensure that flow meters are installed at boreholes and tanks to enable the recording of water consumption for water balance purposes. Flow meters must be serviced annually.
- Integrate the groundwater outcomes into the site water balance to assist with the efficient management of water resources on site and identify and minimise water losses from the system;
- Implement the monitoring, operational and maintenance requirements as outlined in the Water Management Plan (Section 6);
- Schedule borehole maintenance every 2 years unless the monitoring data (yield vs drawdown) indicates more frequent cleaning is required (Section 6.2);
- Locate or drill alternative boreholes to replace the existing boreholes if yields cannot be improved or maintained or to supplement water supply during borehole maintenance periods (after the K5 pit has been drained);
- Establish a covered water storage area nearby to the plant which contains water storage tanks with a minimum capacity of 1 week (~2700 m3) which can provide an emergency water source to the plant;
- Andrada will need to amend their permitted abstraction volume to account for the required 18 m3/hr (127 440 m3/a) required by the plant for the Phase 1 Stage II expansion;

- Locate third-party groundwater users within a 10 km radius of the mine wellfields and confirm their current abstraction requirements and planned future abstraction requirements;
- It is recommended to plan the dewatering of the K5 pit well in advance so the dewatered volumes can be used to meet the plant requirements instead of being discharged to the environment. The water in the pit has higher concentrations of calcium, magnesium, sodium, potassium chloride, sulphate, iron, manganese and electrical conductivity compared to the groundwater samples which may dictate how much of the pit water can be used during a month (if this needs to be diluted with clean or groundwater contributions). The water quality requirements of the plant will therefore need to be defined as soon as possible or the establishment of a water treatment plant could be considered;
- The numerical model must be recalibrated every 2 (two) years to incorporate the latest monitoring data as well as any changes to the water supply network or plant yield requirements. The model will be an asset to Andrada to assess any changes which could affect the water supply for the Project;
- The numerical model can be refined in future updates to simulate climate change responses to the expected rainfall volumes over the life of mine. The IPCC report indicates that drought events in Southern Africa (caused by the El Nino oscillation) are predicted to become more frequent and intense, which could affect the recharge potential to aquifers in the Region.
- Drawing large yields of groundwater for prolonged periods may have significant drawdown impacts for the regional aquifers. Alternative water supply options such as piping water from the Orano Desalination plant or directly from the sea should also be considered for the project.

Table 31 - Water availability impacts post mitigation

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Over-abstraction for mining and processing requirements	Water (availability)	Negative impact on the sustainable yield of the aquifer due to over-abstraction coupled with sub-optimal natural recharge conditions.	Adverse Direct Reversible Short-term Local Probable	Medium	Moderate	Moderate (6) (after mitigation)

7.12 SURFACE WATER IMPACTS

Sediment loading within surface water streams from flood events may have the potential to alter stream bed morphology and pose a risk to nearby property. In arid areas like Uis this can be exacerbated without the proper diversion channels in place around property and infrastructure. The risk of floods inundating the bulks sample, sorting, and testing facility is rated low with proper mitigation in place. If a flood event does occur the duration of the impact will be temporary and limited to onsite infrastructure possible influence.

One of the most significant impacts of mining on surface water is the potential for water quality degradation Table 32. Mining activities can generate contaminants that can enter nearby water sources and lead to pollution. These contaminants can include sediment, heavy metals, and chemicals used in mineral processing. Polluted water can harm aquatic life and create health risks for people who rely on the water for drinking, irrigation, or other purposes. The site has stormwater management and diversions in place to prevent stormwater making contact with mining infrastructure thereby significantly reducing this risk.

Mining activities can impact the quantity of water available in the surrounding environment. Water may be used for mining operations or may be displaced due to mining activities, leading to lower water levels in nearby rivers or groundwater. This can impact the availability of water for other uses and potentially harm ecosystems that rely on consistent water levels. The only aquatic habitat in proximity to the site, is that of the fish farm in the northern open pit, this activity has ceased and therefore there is no longer a receptor relying on constant water supply. The areas is arid and receives seasonal rainfall and rivers do not run permanently. The site utilised a combination of water from the open pits and groundwater and does not intend to abstract water from rivers, therefore this impact is not considered significant.

Mining activities can change the flow of water in the surrounding environment, which can impact habitats and ecosystems. This can occur due to changes in the topography of the land or by diverting water for mining activities. Changes in water flow can impact the quality and quantity of water available in the environment, leading to changes in ecosystems. This is almost certainly going to occur as the site will require some water diversion mechanisms, the impact would be local, reversible and affected in the short term during large rainfall events.

There is the potential for spills or leaks of chemicals or other hazardous materials during mining operations and construction, which can lead to significant impacts on surface water quality. Spills can result in immediate harm to water quality, and can also have longer-term impacts if chemicals persist in the environment.

Overall, the impact from these project change to surface water remains largely unchanged from the current operations. The proponent will need to ensure surface water mitigation measures outline in the EMP are implemented. Such measures include the use of best management practices, implementing appropriate water treatment technologies, and monitoring water quality and quantity regularly.

Table 32 - Surface water impacts

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
Surface water runoff during rainfall events or flood events.	Surface water streams and property	Sediment loading from flood events that may change stream morphology thereby affecting nearby property or infrastructure	Adverse Direct Irreversible Temporary Onsite Possible	High	Moderate	Low (2) (with mitigation)
Surface water mining activities can generate contaminants that can enter nearby water sources and lead to pollution	Surface water quality	Potential for contaminants such as sediment, heavy metals, and chemicals used in mineral processing impacting on surface water quality	Adverse Direct Partly reversible Temporary Onsite Possible	High	Moderate	Minor (3) (with mitigation)
Mining activities can impact the quantity of water available in the surrounding environment	Surface water quantity	Water may be used for mining operations or may be displaced due to mining activities, leading to lower water levels in nearby rivers or groundwater	Adverse Direct Irreversible Temporary Onsite Possible	High	Moderate	Moderate (4)
Mining activities can change the flow of water	Surface water change in water flow	Changes in water flow can impact the quality and	Adverse Direct Partly reversible	High	Moderate	Moderate (4)

Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
in the surrounding environment, which can impact habitats and ecosystems		quantity of water available in the environment, leading to changes in ecosystems	Temporary Onsite Possible			
There is the potential for spills or leaks of chemicals or other hazardous materials during mining operations, which can lead to significant impacts on surface water quality.	Surface water – spills or leaks of chemicals	Spills or leaks of chemicals or other hazardous materials during mining operations, which can lead to impacts on surface water quality	Adverse Direct Partly reversible Temporary Onsite Possible	High	Moderate	Moderate (4)

8 CONCLUSION

A full and comprehensive Environmental and Social Impact Assessment (ESIA) has been undertaken for the UTM Phase 1 Stage II expansion Project. All aspects have been considered in the impact assessment. These aspects have been thoroughly investigated against planned activities. Public participation has been positive with all issues raised considered in the report for the decision making and impact assessment. All specialist input has been considered and the recommended mitigations have been incorporated into the environmental and social management plan (ESMP).

The scoping phase of the ESIA described the receiving environment adequately. Alternatives were provided in terms of water management and water sourcing, these were also assessed by the specialists, of which the results are encapsulated within this report. MEFT granted project approval on the scoping phase however a detailed ESIA has been conducted due to the project significance.

In closing, this ESIA report adequately outlines the process of impact assessment for the UTM Phase 1 Stage II expansion project and lists all the foreseeable outcomes and recommended mitigations to reduce the potential impacts. One impact remained high and rightly so as the Proponent has no influence over external parties abstracting from the same source. The ESMP includes the required monitoring of the project at all stages of the project.

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APPENDIX A – ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

APPENDIX B – PUBLIC CONSULTATION RECORDS

APPENDIX C – EAP CVS

APPENDIX D – BLAST AND VIBRATION STUDY

APPENDIX E – WATER ABSTRACTION PERMIT - OCT 2021 GRANTED

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APPENDIX I – AIR QUALITY BASELINE AND ASSESSMENT STUDY

APPENDIX J – NOISE BASELINE AND ASSESSMENT STUDY

APPENDIX K – TRAFFIC IMPACT BASELINE AND ASSESSMENT STUDY

Submitted to: Uis Tin Mining Company (Pty) Ltd.
Attention: Mr Efraim Tourob
4th Avenue East, Number 1
P O Box 30
Uis

REPORT:

UIS TIN MINE UPDATED OPERATIONAL ENVIRONMENTAL MANAGEMENT PLAN

PROJECT NUMBER: ECC-84-284-REP-13-D
REPORT VERSION: REV 01
DATE: 20 JUNE 2023

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Project Name:	Uis Tin Mine Updated Operational Environmental Management Plan
Client Company Name:	Uis Tin Mining Company (Pty) Ltd.
Client Name:	Mr Efraim Tourob
Ministry Reference:	APP-002920
Authors:	Jessica Bezuidenhout
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ENVIRONMENTAL COMPLIANCE CONSULTANCY CONTACT DETAILS:

We welcome any enquiries regarding this document and its content. Please contact:

Environmental Compliance Consultancy
PO Box 91193, Klein Windhoek, Namibia
Tel: +264 81 669 7608
Email: info@eccenvironmental.com

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ABBREVIATIONS

ABBREVIATION	DESCRIPTION
AMD	Acid mine drainage
CPF	Central processing facility
CWC	Clean water channel
DMS	Dense Media Separation
DWA	Department of Water Affairs
ECC	Environmental Compliance Consultancy
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
EMS	Environmental Management System
EPL	Exploration Prospecting Licence
ESIA	Environmental Social Impact Assessment
GHG	Greenhouse gas
GIS	Geographical Information System
MAWLR	Ministry of Agriculture, Water and Land Reform
MEFT	Ministry of Environment, Forestry and Tourism
ML	Mining Licence
MSDS	Material Safety Data Sheet
NHC	National Heritage Council
ESMP	Environmental and Social Management Plan
POI	Point of interest
PV	Photovoltaic
SLM	Sound level meter
ToR	Terms of reference
TPH	Tonnes per hour
TSF	Tailings Storage Facility
UTMC	Uis Tin Mining Company
WRD	Waste Rock Dump

1 INTRODUCTION

Environmental Compliance Consultancy (ECC) has been retained by Uis Tin Mining Company (Pty) Ltd (hereinafter referred to as the Proponent or UTMC) a Namibian company and subsidiary of Andrada Mining Limited. ECC conducted the environmental and social impact assessment (ESIA) for the proposed Stage 2 expansion of the pilot tin processing plant and the addition of a bulk sample, sorting, and testing facility on Mining Licence 134 (ML134), located near Uis in the Erongo Region, Namibia.

Tin was discovered at Uis by the German Colonial Gesellschaft in 1911. Mining commenced in 1923 under the name of Namib Tin Mines Ltd. After a few changes in ownership Imcor Tin (Pty) Ltd bought Uis in 1958. Imcor steadily enlarged the capacity of the mine and also started to develop the town of Uis, providing infrastructure and service facilities as well as housing for employees. In 1980 capacity was again enlarged to become the largest hard-rock tin mine in the world. Operations ceased as a result of depressed tin prices in 1990.

UTMCs commitment to ensure suitable and responsible mining practices are in place, which is demonstrated through a corporate commitment to ensure the protection of the environment and communities in which they operate. UTMC has a duty to ensure that all regulatory and company standards with regards to the environment are met and complied with. In addition, UMTC is responsible for the protection of the environment that may be impacted as a result of site operations and activities.

1.1 ANDRADA MINING LIMITED

Uis Tin Mine Company is a subsidiary of Andrada Mining with a portfolio of assets in Namibia. The company was established in 2017 and listed on the Alternative Investment Market (AIM) in November 2017, to acquire the tin assets of Bushveld Minerals Limited, an AIM quoted Natural Resource Company.

Andrada is listed on AIM, of the London Stock Exchange (LSE), and the Namibian Stock Exchange. Andrada has a vision to create a portfolio of world class, conflict-free, technology metals. The company's top assets are the tin, tantalum and lithium rich resources in the Uis area.

Andrada's management includes an experienced board of directors and a management team with a current two-fold strategy – to fast track the Uis brownfield tin mine in Namibia for commercial production and consolidation of other quality African tin assets. Andrada strives to capitalise on the solid supply or demand fundamentals of tin by developing a critical mass of tin resource inventory, achieving production in the near term and further scaling production by consolidating tin assets in Africa.

1.2 UIS TIN MINE

Uis is a small town in the Erongo Region, Namibia approximately 330 km from Windhoek. The town can be accessed via the C36 from Omaruru or from the cost via Henties Bay. The mine site consists of three separate mining licences namely; ML129, ML133, ML134, each of which has been historically exploited for tin on varying scales as shown in Figure 1. Currently all construction activities are carried out on ML 134. The total size of ML 134 is approximately 197 km^2 and the mining footprint is 8 km^2, which is <2% of the licence area. Limited activities are currently taking place on ML 133 and ML 129 however there are plans for near future development.

Uis has a JORC compliant resource of 81 million tonnes at 0.15% tin (Sn), 0.73% lithium (Li2O) and 82 ppm tantalum (Ta)., Additionally, Andrada has a JORC compliant resource over the other Uis pegmatites totalling 53 million tonnes with an average grade of 0.13% Tin. The company has also recently announced a new lithium resource in the project area.

Uis Tin Mine is situated on a topographical belt associated with the escarpment, between the Namib Desert and the Central Plateau of Namibia. Climatic conditions are associated with a transition between the semi-arid (east) and the arid (west) parts of Namibia.

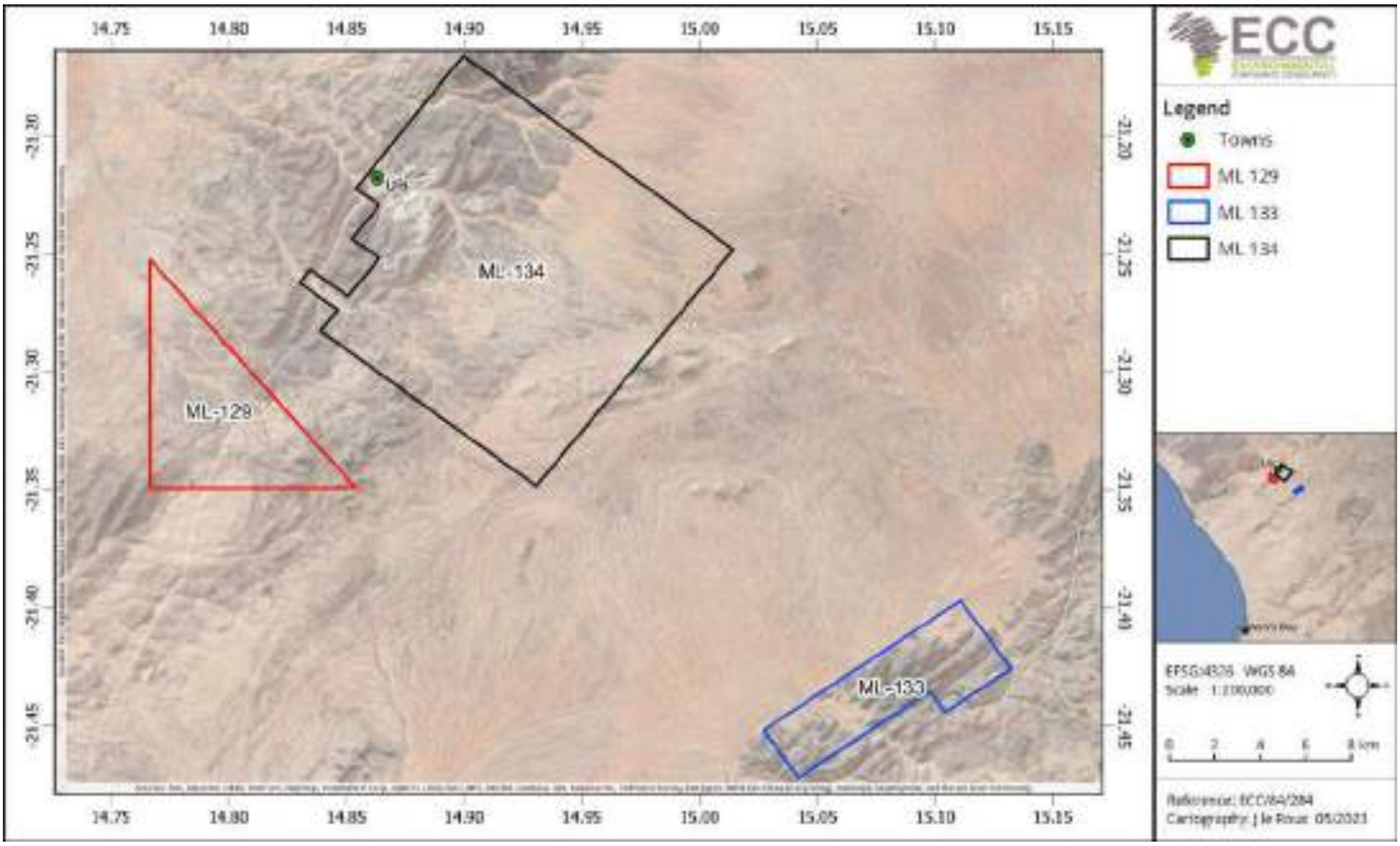


Figure 1 - UTMCs mining licence areas

The tin at the Uis Tin Project is hosted in a large pegmatite deposit. The deposit will be utilised in two phases, namely Phase 1 and Phase 2. Phase 1 of the project involves using a pilot plant, and a 1:1.5 stripping ratio is expected during this phase with an estimated production of approximately

65t of concentrate per month. The project will then advance into Phase 2, consisting of a full-scale processing plant, during which time a stripping ratio of approximately 1:1.5/2 is anticipated, yielding approximately 460 tonnes per month of tin concentrate . The operation is designed to produce 95 640 tonnes of mineral using a Dense Media Separation (DMS) plant. Existing waste dumps will be used to dispose of waste produced from mining. Three waste dumps have been identified for use during Phase 1 and therefore no additional waste dumps will be created during Phase 1 mining. The tailings (blended coarse and fine plant discard) produced will be co-disposed with waste rock onto the waste dumps and a filter press system will be used for recycling approximately 85% of water. The latter is a critical component of the design consideration for the project plant.

1.3 CHANGES TRIGGERING THE AMENDMENT

Since 2019, Andrada has been in the process of restarting and enhancing production at the Uis Tin Project. The site is located in the historical mining town of Uis in the Erongo Region, Namibia as shown in Figure 2. The tin is hosted in pegmatite deposits, the primary minerals is cassiterite and secondly tantalum. The Proponent proposes several mechanical and process flow upgrades to components of the current pilot plant's processing and supporting infrastructure (i.e., upgrades to the Dense Medium Separation (DMS) 1 cyclone feed, inlet pressure system rates and constant moisture control within feed material, etc.). This upgrade is expected to increase the production rate from the current 80 tons per hour (TPH) in Stage 1 to 120 (TPH) in Stage 2. The Mine also intends to build a bulk sample processing facility adjacent to the existing processing plant. The purpose of the bulk sample processing facility is to undertake metallurgical test work on the material from the existing mine pits, as well as from external areas where exploration work is being undertaken to assess the process required to extract minerals from the ore(s).

The Proponent intends to implement the proposed upgrades, as well as on-site supporting infrastructure, to be able to sustain and support the planned expansion project. The additional changes and upgrades include the following which are all addressed and managed under domain 4 processing plant:

The additional changes associated with this amendment and project change include:

- Upgrades to the existing sewage effluent water collection and treatment system
- Building a clean stormwater channel (CWC) and berm around the plant for water re-use in the processing circuit
- An upgrade of the existing settling and evaporation ponds
- Increased water supply (from 75 000 to 150 000 cubic meters per year), now part of the amended abstraction permit.
- Bulk sample processing facility
- New, but limited in spatial extent, haul and access roads will be constructed to access the bulk sampling, sorting, and testing facility.

These upgrades are designed to consistently achieve a targeted tin recovery of 64% and they form an integral part of the 20-year life of mine (LOM).

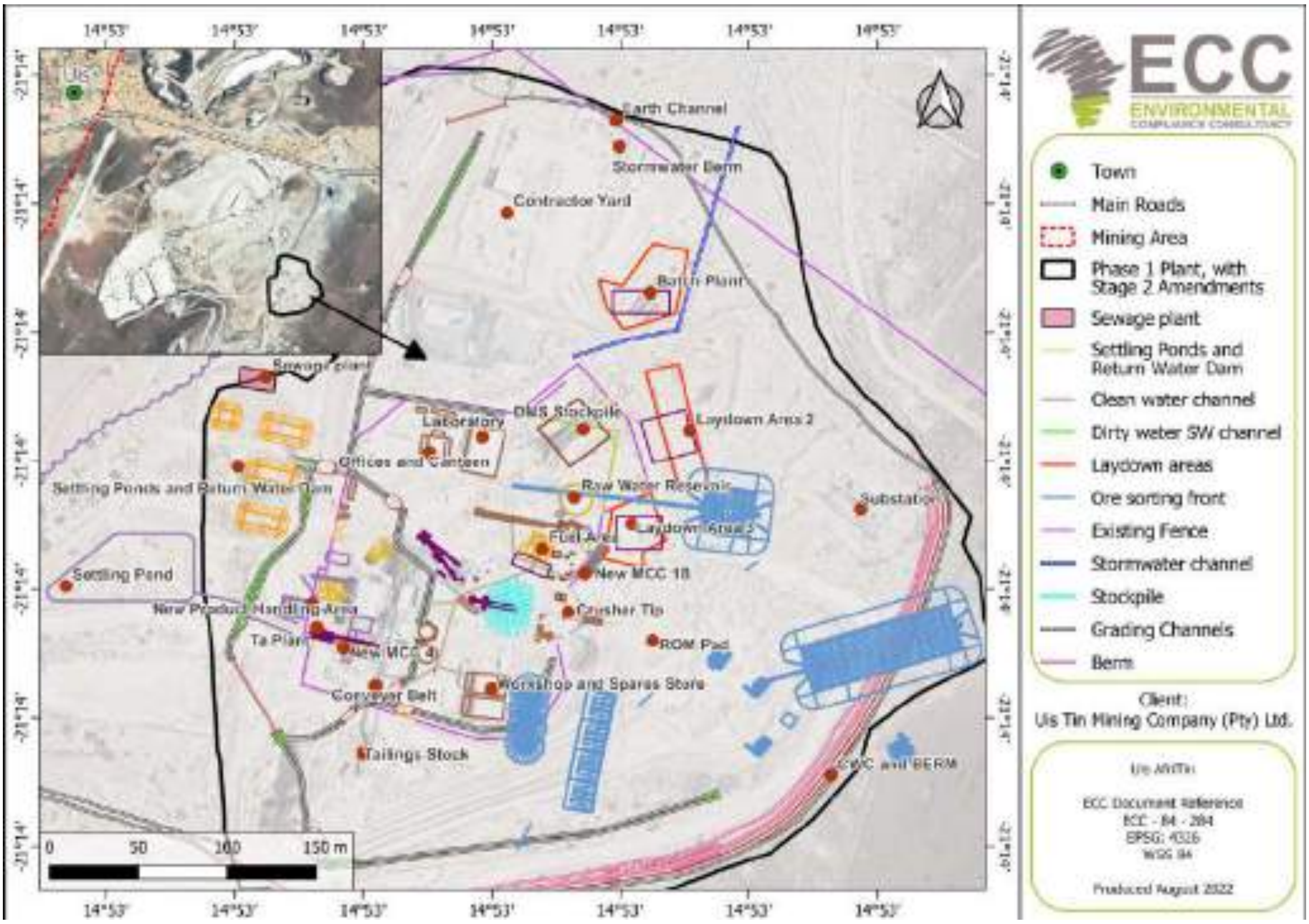


Figure 2: Location of the proposed expansion elements of the pilot tin processing plant on ML134

1.4 Purpose of the OEMP

This amended operational environmental management plan (OEMP) is a site-specific plan developed to ensure that appropriate environmental management practices are followed during the construction, reopening and operational phase of a project. This OEMP has been prepared to address environmental risks associated with the operations at the Uis Tin Mine.

The OEMP is a 'live' document, which shall be reviewed annually and periodically updated to reflect material changes to the operations and to allow continual improvement for environment and community management on the Uis Tin Mine site.

This OEMP has been approved by the site's Mine Manager and therefore it can be implemented across all activities at the Uis site. ECC has compiled this operational environmental management plan (OEMP) in terms of the Environmental Management Act (EMA), No.7 of 2007 and its regulations of 2012.

The purpose of this amended OEMP is to support the full environmental and social impact assessment (ESIA) report for the expansion and changes of the Uis operation. The OEMP has been updated since the submission of the final scoping report, to incorporate information from additional specialist studies that form part of the ESIA report.

1.5 ENVIRONMENTAL REGULATORY REQUIREMENTS

The Uis Tin Mine and associated activities trigger a number of listed activities as set out in the Environmental Management Act, 2007 (Act No. 7 of 2007) and its gazetted Environmental Impact Assessment Regulations (No. 30 of 2011).

The site has an approved environmental clearance certificate to undertake these listed activities in accordance with the Act. As per the Act and its Regulations, this certificate is required to be renewed every three years. This OEMP supports compliance with the Uis Tin Mine site's environmental clearance certificate and shall be submitted to the Department of Environmental Affairs, in the Ministry of Environment, Forestry and Tourism for endorsement.

1.6 LEGAL COMPLIANCE

The Uis Tin Mine management team holds a copy of the environmental clearance certificate and is responsible for ensuring clearance certificates to be in place prior to works associated with listed activities, and ensures they are current, up to date and renewed on the basis required by the Act.

UTMC holds their responsibilities in line with the legal framework and provides a statement of commitment to comply with the provisions of the regulatory arrangements set out in the OEMP. Figure 3 sets out a declaration of commitment.

ANDRADA MINING LIMITED – UIS TIN MINE

DECLARATION OF COMMITMENT

On behalf of the Uis Tin Mine, I hereby declare my unwavering commitment to ensure that appropriate and leading environmental management practices are followed at the Uis Tin Mine site.

Furthermore, I will ensure that the relevant management plans, procedures, and internal policies for the site are established. I hereby offer this commitment on behalf of the Uis Tin Mine team to ensure the protection of the environment and community in which they operate.

Yours Sincerely,

____

Mr Efraim Tourob

Mine Manager – Uis Tin Mine

Figure 3 - Declaration of commitment

1.7 SCOPE OF THIS OPERATIONAL ENVIRONMENTAL MANAGEMENT PLAN

This OEMP has been developed by adopting a collaborative and integrated approach to environmental management. It is based on the findings from the ESIA conducted for the proposed changes to the project site.

Obligations and commitments made in the superseded plan have been incorporated into this OEMP; where commitments are no longer applicable, or are redundant, they have been removed. The site's environmental and social impact assessment (ESIA) report as well as the experience and knowledge of the authors have been used to compile this OEMP. This OEMP aims to avoid repeating information, procedures or guidance that are available in other site and company reports, and has been written in line with the Namibian Government guidance document titled "Draft Procedures and Guidelines for Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP), 2008".

This OEMP has been prepared to reflect the entire mine's life cycle. The mine is currently in the operational phase and intends to move into advanced operations in 2023 and beyond. The OEMP will be used to tie into the decommissioning and closure plan framework as well. The geographical scope of this OEMP includes all operations and activities within the boundary of Mining Licence 134, 133 and 129 and includes monitoring requirements for the mining licence areas. These activities are categorised work areas, termed "domains", which are separated by operational activities, with the long-term view of integrating the OEMP into the decommissioning and closure plan for Uis Tin Mine. Standard operating procedures (SOPs) feed into this OEMP, allowing a holistic environmental management approach to be adopted across the site. Health and safety management measures are not included in this OEMP.

1.8 ENVIRONMENTAL CONSULTANT

Environmental Compliance Consultancy (ECC), a Namibian consultancy registration number Pty Ltd 2022/0593, has prepared this OEMP on behalf Uis Tin Mine. ECC operates exclusively in the environmental, social, health and safety fields for clients across Southern Africa, in the public and private sector. ECC is independent to the proponent and has no vested or financial interested in the proposed project.

ECC has over 25 years combined construction and operational experience in the fields of mining and metals, nuclear and renewable energy plants. Through this experience ECC has been involved with developing and implementing several operational environmental management plans for projects of various scales and hazard risks; including but not limited to gold, copper, nickel and vermiculite mining operations in Australia, nuclear power plants in the United Kingdom, renewable energy plants in South Africa and Namibia.

ECCs team focuses on ensuring environmental management is practical, implementable and useable on the ground to ensure the impacts are minimised to the environment and community in which the site operates. This is reinforced with specific environmental monitoring objectives and the OEMP has been verified and approved by the ECC team.

1.9 STRUCTURE OF THIS OEMP

As this is an operational environmental management plan it is assumed that the reader is familiar with the site. If the reader requires further details on the site and its operations, the environmental and social impact assessment report for Uis Tin Mine should be referred to (ECC, 2023).

The layout of this OEMP has been set up to provide site-specific and relevant information in the main sections of the report and provides supporting or supplementary information in the appendices, thereby providing the end user with an operational document for ease of use.

The targeted users of this OEMP are heads of the departments (HODs), the site environmental team and the authorities or stakeholders with a vested interest in how the Uis Tin Mine manages its environment and social responsibilities. The OEMP structure is summarised in Table 1.

Table 1 – Report structure

Chapter	What this chapter addresses
Chapter 1	Broad overview of the site and the purpose of the OEMP
Chapter 2	Sets out the company integrated management system and how this OEMP is managed and enforced
Chapter 3	Sets out the OEMP and the various domains and domain schedules
Chapter 4	Sets out the site's environmental schedules and provides a customised OEMP for each domain (work area), setting out the responsibilities; the activities in the work area and potential impacts; operational management measures; environmental pollution control measures; monitoring requirements; and reporting expectations.

Appendices to support the OEMP and the implementation thereof are as follows:

- Appendix A – Environmental monitoring programme and trigger values
- Appendix B – Domain sign off and certification
- Appendix C – Grievance submission form
- Appendix D – Domain checklists
- Appendix E – Weed and seed clearance certificate
- Appendix F – Environmental improvement plan
- Appendix G – Land clearing permit
- Appendix H – Standard operating procedure –water quality monitoring
- Appendix I – Standard operating procedure – air quality monitoring
- Appendix J – Standard operating procedure – ambient noise monitoring

- Appendix K – Supporting documents

1.10 Assumptions, Limitations and Uncertainties

During the development of this OEMP, assumptions have been made based on the scope and scale of the project and limitations and uncertainties have been identified. The assumptions, limitations and uncertainties are as follows:

- The old tailings storage facility (TSF) is not considered within the operational control of the site, furthermore the mining strategy has mitigated the need for the construction of a TSF or use of the existing TSF and therefore has not been included in this OEMP.
- The site does not have a bio-remediation facility currently, however due to the nature of the operations a bio-remediation facility will be required and therefore has been included within this OEMP, and
- This OEMP does not include measures for compliance with statutory occupational health and safety requirements. This will be provided in the safety management plan to be developed by the Proponent.

Where there is any conflict between the provisions of this OEMP and any contractor's obligations under their respective contracts, including statutory requirements (such as licences, project approval conditions, permits, standards, guidelines, and relevant laws), the contract should be amended, and statutory requirements are to take precedence.

The information contained in this OEMP has been based on the project description as provided in the ESIA report. Where the design or construction methods are different, this OEMP may require updating and potential further assessment may be undertaken.

2 OPERATIONAL ENVIRONMENTAL MANAGEMENT PLAN

This OEMP provides measures, guidelines and procedures for managing and mitigating potential environmental issues during the operations of the site. It also indicates monitoring and reporting guidelines and sets responsibilities for those carrying out management and mitigation measures. One of the aims of this OEMP is to act as an umbrella document that drives a holistic iterative approach to environmental management across the Uis Tin Mine site.
The incorporation of the company's integrated management system into this OEMP ensures that silo working across domains is avoided, and a holistic environmental management approach is implemented across the site.

2.1 ORGANISATIONAL STRUCTURE, ROLES AND RESPONSIBILITIES

The site's environmental commitments are managed at various levels across the organization and is supported by an on-site appointed HSEC manager. The site appointed HSEC Manager reports to the site General Manager and Mine Manager, and is responsible for the management and strategic direction, and advisory services on all environmental related matters to support Uis Tin Mine operations. The site has been divided into various domains, for which mitigations and environmental management measures are set out. Each domain is supervised by a domain manager.

2.2 REVIEW OF THIS PLAN

This OEMP shall be reviewed and updated as required and shall be submitted to the MEFT every third year to accompany the application for the renewal of the environmental clearance certificate (in line with current legal requirements) or submitted to MEFT for endorsement as required.

2.3 COMPLIANCE, INSPECTIONS AND ENFORCEMENT

The environmental risks and impacts associated with the operations and activities of the Uis Tine Mine are detailed in each environmental schedule, along with specific mitigation and operational management arrangements.

A copy of this OEMP will be available to all personnel and hard copies shall be available across site. All personnel shall comply with this OEMP through their daily roles and any activities undertaken.

The appointed environmental control officer (ECO) shall undertake regular inspections; the type and frequency will be determined based on the level of risk associated with the activities and operations performed in each domain. For the higher risk areas, inspections shall be no less than weekly, and supervisors shall inspect their area of responsibility no less than monthly. The purpose of these inspections is to ensure this OEMP is being complied with.

Work areas and work tasks shall be inspected by the domain manager, which will be an experienced and qualified person. Conditions, controls and practices in and around the work area shall be inspected and inspections shall be both visual examinations and discussions with personnel.

Specialised inspection programs shall be implemented to ensure that equipment and processes with a high risk of causing harm are inspected routinely or (where applicable) to meet either internal and/or statutory requirements. The inspection schedules for each domain shall be maintained and a record of each inspection shall be produced by the appointed ECO. Any corrective or preventative actions shall be communicated to the environmental team as soon as the inspection is complete.

2.4 NON-COMPLIANCE

The proponent and all companies and businesses operating on the project site shall ensure that this OEMP is fully complied with by contractors and personnel. All non-compliance events shall be reported via the incident reporting system and the standard reporting process that includes ensuring preventative action, reporting and where required taking disciplinary action.
Non-compliance events can be considered as:

- Evidence of contravention of this OEMP and associated indicators
- Failure of personnel to comply with corrective action or other instructions instructed by the operational manager, and
- Failure to address and respond to community complaints.

3 DOMAINS AND ENVIRONMENTAL SCHEDULES

Uis Tin Mine operates in distinct operating zones/work areas that are defined as domains. Through defining these domains, clear operating areas are established. Each domain has a concise environmental management plan, known as a domain schedule.

Within each domain, a domain manager is assigned and is responsible and accountable for the management of the environment within the domain and who shall ensure that the domain schedule is reviewed to ensure no additional environmental risks or impacts are occurring.

The appointed ECO shall ensure that all measures are implemented to mitigate and manage environmental risks; e.g. ensuring pollution control measures, and that monitoring and reporting associated with the domain are in place. The domains for the Uis Tin Mine site have been set out in Table 2.

Table 2 – Uis Tin Mine domain schedule of areas within the operational control of UTMC and addressed within the scope of this OEMP

Description		Includes	Domain manager
Domain 1	Linear Infrastructure	Access roads and tracks Powerlines Water abstraction boreholes, pipelines, and management thereof	Technical Services Manager
Domain 2	Open pit and mining area	Open pits Mining offices and change house	Technical Services Manager
Domain 3	Co-disposal and waste rock dumps (WRD)	Hauling and dumping of mineral waste rock/material from the open pit Hauling and co-disposal of blended tailings/plant discard with waste rock Landform sloping and design Bulldozing and levelling of waste rock	Technical Services Manager
Domain 4	Processing plant	ROM Crushing circuit Processing plant and associated infrastructure Bulk sample processing facility Clean water channel, stormwater management system Sewerage, settling and water return ponds Processing plant workshop	Processing Manager supported by the Engineering Manager
Domain 5	Workshops	Heavy and light vehicle workshops Contractors workshops Wash bay Excavator pad Tyre workshop	Technical Services Manager Supported by Engineering Manager

Description		**Includes**	**Domain manager**
		All mobile maintenance activities for infield emergency repairs, maintenance or servicing of equipment	
Domain 6	Fuel Depot	62,000 lt of diesel fuel Fuelling bay	Supply Chain Officer and General Manager
Domain 7	Salvage yard and non-mineralised waste facility	Salvage yard	Engineering Manager
Domain 8	Old Contractors camp/s	Camp site	Technical Services Manager
Potential future domain	Bioremediation facility	Bioremediation facility for the onsite treatment and rehabilitation of hydrocarbon contaminated soils	Technical Services Manager supported by the General Manager

3.1 Areas outside Andradas operational control

Due to the site's long and extensive mining history, Andrada has strategically identified areas within (depicted in green in Figure 4) and outside (depicted in red in Figure 4) of their operational control. This approach has been adopted to limit the impact of the current mining activities. Areas outside of Andradas control are therefore not addressed in this OEMP and are listed below:

- Existing waste rock dumps;
- Existing TSF;
- 'White' tailings stockpiles; and
- All non operational areas located within the ML for example the town of Uis and its related infrastructure.

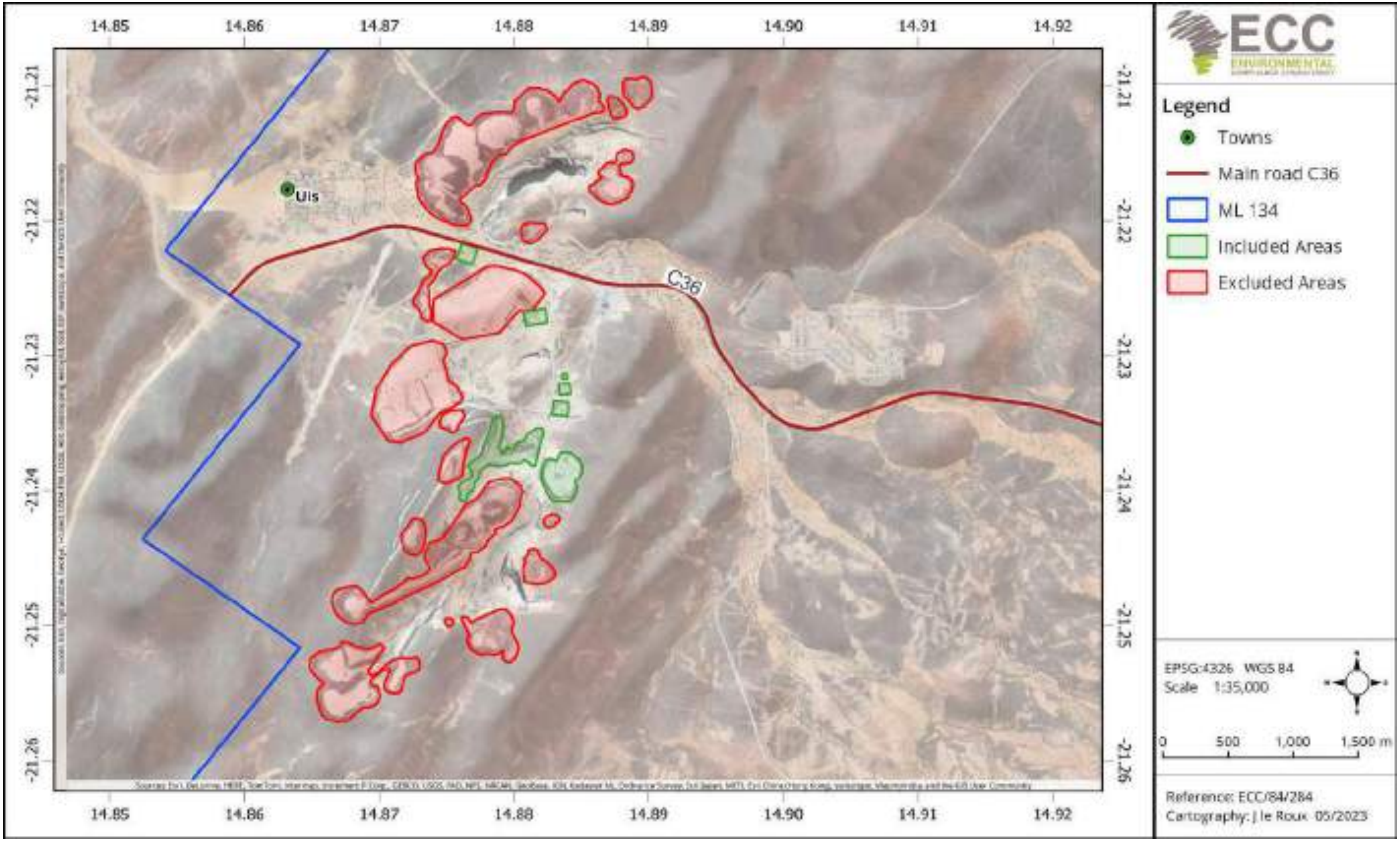


Figure 4 – Areas within and excluded of UTMCs operational control

3.2 Environmental Monitoring

3.3 Surface water quality monitoring

Surface water has been regularly monitored at the northern pit (K5), the southern pit, Ralph's Pond, the Bleed water pond and the V1/V2 pit. The northern pit and the southern pit are historic mining pit voids that have accumulated water over time. The V1/V2 pit is also monitored when surface water is present.

The water from the northern pit is now used for operational purposes and when the site was not in operation it was used for an aquaculture fish farm project. Ralf's ponds waters are a mixture of the "grey water" emanating from the onsite sewage system and the processing plant.

The objective of monitoring surface water is to establish the surface water quality within the operational area of the mine and to continue to build the operational dataset to compare against the baseline water quality data. This information is then used to draw a conclusion on the impacts of mining activities on water quality.

Surface water monitoring is also required at the toe of the waste rock dumps after heavy rains as stated in Domain 4. It is recommended that sampling or water quality monitoring points are placed at suitable locations for recycled process water.

Additional surface water monitoring sites may be added to this programme as the site develops and evolves, and as the need arises.

3.4 Groundwater level and quality monitoring

Groundwater levels are measured monthly to assess the water level of the aquifers and the possible impact of abstraction on the water systems. Monitoring is required to understand the quality of groundwater prior to, and during mining operations in order to determine the impacts on groundwater from mining operations. A number of monitoring locations have been established for the site based on previous studies on the groundwater quality in Uis, this data serves as baseline ground water quality data for the operation. Monitoring of groundwater in proximity to the waste rock dumps is required. The locations of the monitoring boreholes is presented in Figure 5.

Figure 5 – Ground and surface water quality monitoring locations

3.5 AIR QUALITY MONITORING

Air quality monitoring locations were established prior to the onset of mining operations as shown in Figure 6. These sites are updated as required as the mine moves into the advanced operational phase. A dustfall monitoring network is set up by following the American Society for Testing and Materials Standard (ASTM D1739-98) method for collection and analysis of dustfall at each of the illustrated sites. Passive sampling will include collecting SO2, NO3, and dust fall samples. Monitoring during the operational phase will focus on Total Suspended Particulates (TSP), PM10 and PM2.5 and Sulphur dioxide (SO2) as shown in the monitoring plan (Appendix A).

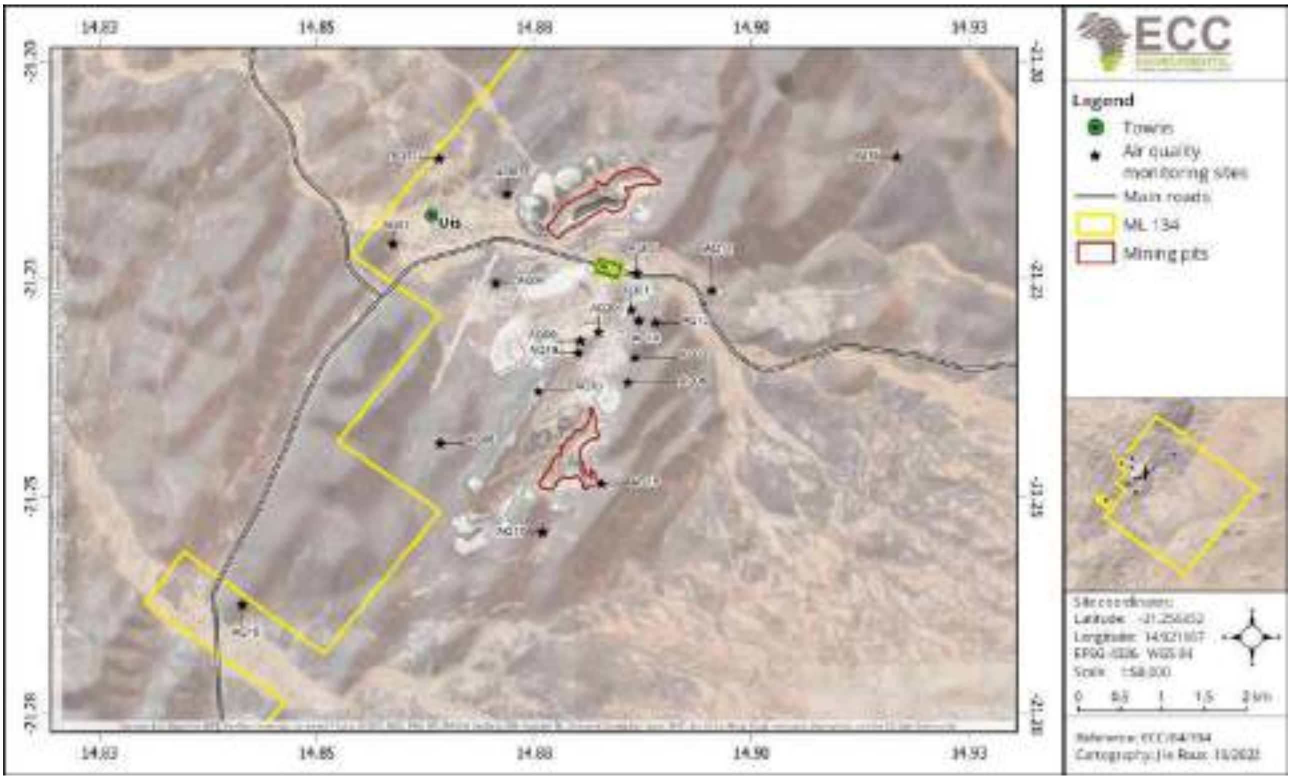


Figure 6: Air quality monitoring locations

3.6 NOISE MONITORING

Ambient noise levels have been monitored in locations in close proximity of nearby sensitive receptors to determine the noise levels in the area prior to the onset of mining operations. The locations of the noise monitoring stations are shown in Figure 7. The nearby sensitive receptors have been identified as the village council building, the Namclay brick factory and the houses situated in close proximity to the Namclay brick factory, although all residents of Uis can be regarded as potential receptors. Monitoring is undertaken on an annual basis or as required.

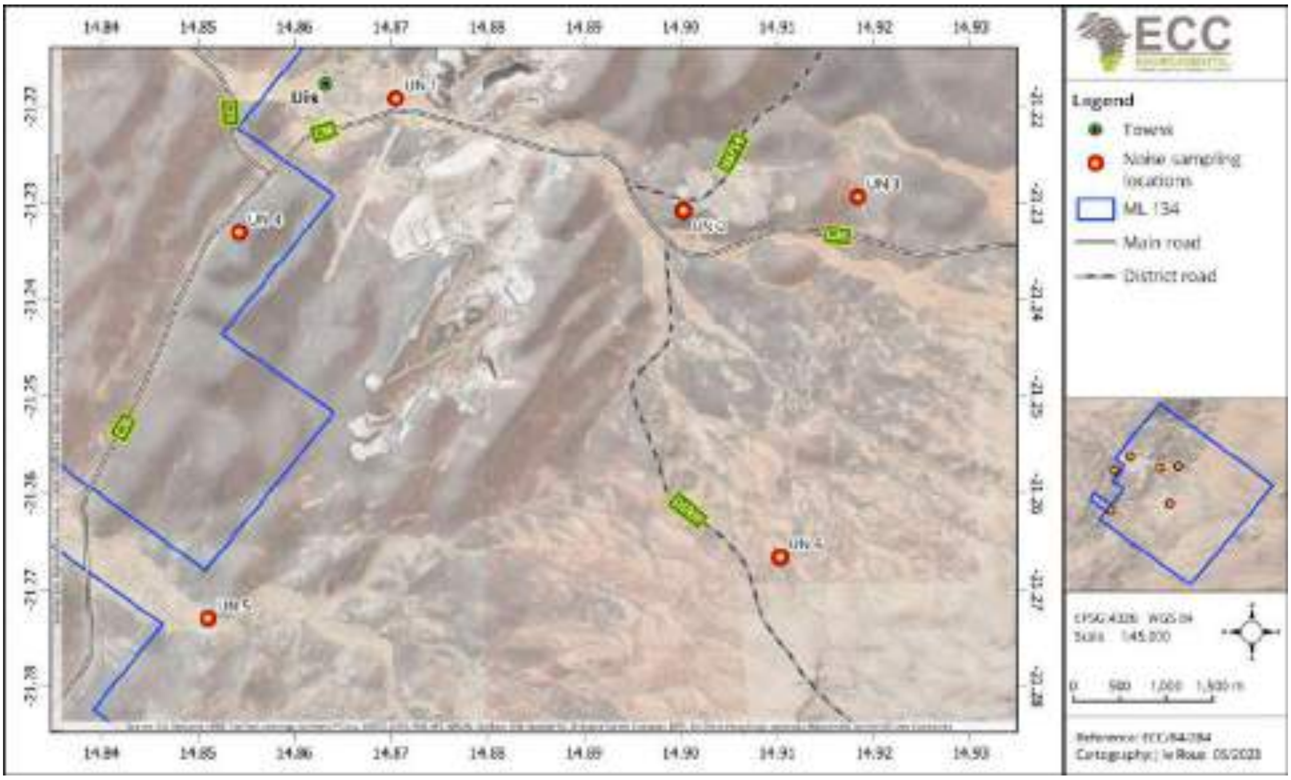


Figure 7: Noise monitoring locations

3.7 CONTINUAL IMPROVEMENT

The appointed ECO of the Uis Tin Mine is responsible for reviewing and updating this OEMP. Obsolete documents are to be promptly removed from circulation and relevant personnel made aware, thereby preventing unintended use.

As part of this review process, the monthly reports from each domain will be reviewed, identifying any trends or significant areas of concern, as well as measures implemented to manage/resolve the environment or social issues. Compliance and legislative changes shall be reviewed, and lessons learnt shall be captured. This OEMP shall be amended as required, and follow up training, awareness or updates shall be provided in the domain(s) and across the site.

This OEMP shall be circulated to all domain responsible positions and stakeholders as required. It will be made available to all those inducted on site and presented in the environmental awareness training and site induction.

Ongoing hazard identification through the review of this OEMP and supporting management plans and SOPs shall ensure environmental impacts are avoided or minimised as low as reasonably practicable.

4 OVERARCHING ENVIRONMENTAL MANAGEMENT PRINCIPLES

4.1 INTRODUCTION

This section sets out the overarching environmental principles that are applicable across all domains and environmental schedules on the Uis Tin Mine site. Environmental schedules set out the site-specific environmental management requirements for the Uis Tin Mine. The environmental schedules have been separated per domain and includes potential issues or impacts that the specific work area may create. It provides the management measures or mitigation measures in place to manage the impacts, it sets the targets and objectives for the domain, outlines the monitoring and reporting requirements and provides clear roles and responsibilities for those managing the domains.

In accordance with best practice the following information is provided in each domain schedule: roles and activities in the domain, environmental risks; objectives for managing the impacts; environmental objectives and targets; management measures; environmental protection equipment; monitoring requirements; and reporting requirements.

4.2 BEST PRACTICE MANAGEMENT MEASURES

The overarching general best practice management measures that shall be complied with across site are listed in Table 3. The domain manager for each domain is responsible for complying with the measures set out in Table 3 where applicable.

Table 3 – Best practice environmental management

ENVIRONMENTAL ASPECT	BEST PRACTICE REQUIREMENT
Pollution prevention control	- Plant and equipment to be maintained and serviced regularly - Refuelling at designated locations - Spill kits available where the risk of loss of containment is identified - Bunds to be at least 110% of the container - Good housekeeping (no littering and adequate waste bins) - Ensure lights are downward facing to reduce light pollution at night
Solid waste management	- Good housekeeping (no littering and adequate waste bins) - Designated waste collection areas around site and one central disposal location - Bins labelled and colour coded - Waste to be separated and kept clean and tidy - Waste bins emptied on regular basis
Ground contamination	- Refuelling shall be undertaken in designated areas with spill kits available

ENVIRONMENTAL ASPECT	BEST PRACTICE REQUIREMENT
	- Hydrocarbon spills to be promptly cleaned and disposed of correctly - Chemical management enforced on site - Good housekeeping
Soil management	- Topsoil is to be recovered in all cases of land clearing - Topsoil to be stockpiled upstream of potential contamination areas
Storage of fuels, oils, chemicals and other hazardous liquids	- Storage tanks shall be suitable and labelled for the liquid being stored - Storage tanks to be stored in an appropriate areas with adequate ventilation and not to be stored with any flammable materials - Bunds to be at least 110% of the container - Daily inspections of tanks
Energy efficiency	- Plant and equipment to be maintained and serviced regularly - Turn off plant and equipment when not in use - Lights in and around the plant to be turned off during daylight hours
Air quality and dust suppression	- Maintenance of internal roads, including dust suppression - Turn off plant and equipment when not in use - Plant and equipment to be maintained and serviced regularly
Landscape and biodiversity	- Control the spread of weeds through weed and seed inspections prior to equipment being used on site. - Relocation of any protected plant species that need to be removed for land clearing purposes. - Ensure lights are downward facing to reduce light pollution at night
Noise and vibration	- Work hours should be restricted to between dusk and dawn where mining involving the use of heavy equipment, power tools, and the movement of heavy vehicles is within 500 m of sensitive receptors.
Water	- Water use hierarchy – use recycled water as far as possible in the plant - Minimise water discharge from the process into the environment - Responsible water use in the work place (e.g. no hosepipes left running); and - Identify and fix all water leaks timeously. - Track water consumption/use from all areas through installed flowmeters with the aim of a closed circuit.

4.3 Environmental Monitoring

Monitoring also supports environmental management on site to evaluate how effective the environmental management has been, over an extended period of time. A consolidated environmental monitoring schedule is provided in Appendix A. Standard operating procedures

(SOPs) were developed to provide further detail of the monitoring programme and specific requirements (Appendix D and Appendix H - J).

The appointed ECO is responsible for the site approved environmental monitoring programme implementation across the site. The monitoring programme comprises of:

- Air monitoring (using samplers at locations within the site boundary and nearest to sensitive receptors),
- Noise and vibration monitoring;
- Water monitoring (e.g., surface water, groundwater levels and quality, and discharge water);
- Biodiversity monitoring (e.g., fauna, vegetation);
- Meteorological monitoring (e.g., rainfall and evaporation); and
- Carbon footprint monitoring (as required).

The domain schedules state the specific monitoring requirements and SOPs. The appointed ECO is tasked with conducting the monitoring within each domain with the support of the domain manager and in line with the monitoring plan as discussed above. The domain manager must ensure the following:
Monitoring is conducted,
The area is safe to allow monitoring personnel access,
Access to the area is granted upon request, and
Reviews the monitoring information related to their domain.

4.4 ENVIRONMENTAL OBJECTIVES AND TARGETS

Environmental objectives and targets have been developed so that activities on the site can minimise potential impacts on the environment, as far as reasonably practicable. These objectives align to environmental and biodiversity performance standards and are applicable to all domains on site. They also form a foundation in developing specific objectives to each domain.

- Zero pollution incidents,
- Sustainable resource use,
- Application of the waste management hierarchy,
- Sustainable use of water,
- Responsible disposal of waste,
- Minimise aerial discharges and dusts being generated,
- Minimise noise and vibration levels, and
- Biodiversity protection and enhancement.

Procedures for monitoring site activities against these environmental objectives are detailed in supporting management plans under this OEMP.

4.5 DOCUMENT CONTROL AND RECORDS MANAGEMENT

Document control and records management sets out requirements to ensure that necessary documentation, records, data and information exist to support the functionality and effectiveness of the Uis Tin Mine.

4.6 NON-ROUTINE OPERATIONS

For all new and non-routine activities that occur on site a specific risk assessment will be conducted. Risk assessments must capture environmental and social risks and must be reported in the monthly report to the appointed ECO, who will then ensure that the relevant documents are updated to reflect the new activity.

4.7 ACCIDENTS AND EMERGENCIES

All incidents, near misses, complaints or concerns from members of the local community or other stakeholders shall be reported in a timely and factual manner; accurately classified; effectively investigated; corrected and prevented from reoccurring through implementation of additional or more effective controls. All incidents are reported on site in accordance with site incident reporting procedures.

An emergency is any abnormal event, which demands immediate attention, usually by adopting a team approach to line management within the affected part of the site or operation. It is any unplanned event, which results in the temporary loss of management control at site, but where functional resources can manage the response. The sites emergency response plan document manages the response in relation to emergencies including environmental emergencies. Emergency response and management falls outside the scope of this OEMP and therefore is not further discussed within the OEMP. Emergency contact details are provided in Table 4.

Table 4 – Emergency contact details

Town	Ambulance	Police	Fire brigade	Onsite Emergency Contact
Uis	+264 (64) 57 0037/ Toll Free 924	+264 (64) 1-0111	+264 (64) 57-0028	+264 814 335 109

For large-scale spills (>200 lts) and other significant environmental incidents, the fire services should be contacted as required and the office of the Ministry of Environment, Forestry, and Tourism (MEFT) informed of the incident (telephone +264 61 284 2111). All correspondence with MEFT should be undertaken by the General Manager.

For the clean-up of smaller spills, the relevant material safety data sheet (MSDS) should be consulted to determine the appropriate clean-up procedure. Basic spill response training will be provided (and regularly tested) as part of the site environmental induction, spill response equipment, including relevant MSDS copies, will be provided in areas where potentially environmentally hazardous chemicals may be used.

The appointed ECO will be the primary contact person in the event of an environmental emergency.

The appointed ECO has the authority and independence to request reasonable steps to be taken to avoid or to minimise unintended or adverse environmental impacts. If preventative steps appear to be ineffective the officer can cease immediately the process, should an adverse environmental impact be anticipated.

4.8 Change Management

Any changes on site, such as mining and management of waste rock or mineral processing methods and tailings management, are subject to the change management process. The change management process ensures that identified modifications or newly introduced equipment, systems, processes, etc. are effectively assessed to determine their associated hazards and level of risk to employees and the environment. The extent of the assessment shall be appropriate to the nature of the change and level of potential risk.

Recommendations or improvements for the site as identified in the environmental improvements plan (Appendix F), shall be reviewed and may be subject to the change management process. This OEMP shall be revised annually taking into consideration changes and associated risk and impacts.

DOMAIN 1 – LINEAR INFRASTRUCTURE

This domain includes tasks for miscellaneous surface infrastructure and activities, which are mapped below Figure 8 and set out in Table 5

- Access roads or tracks;
- Water abstraction boreholes and pipelines; and
- Powerlines.

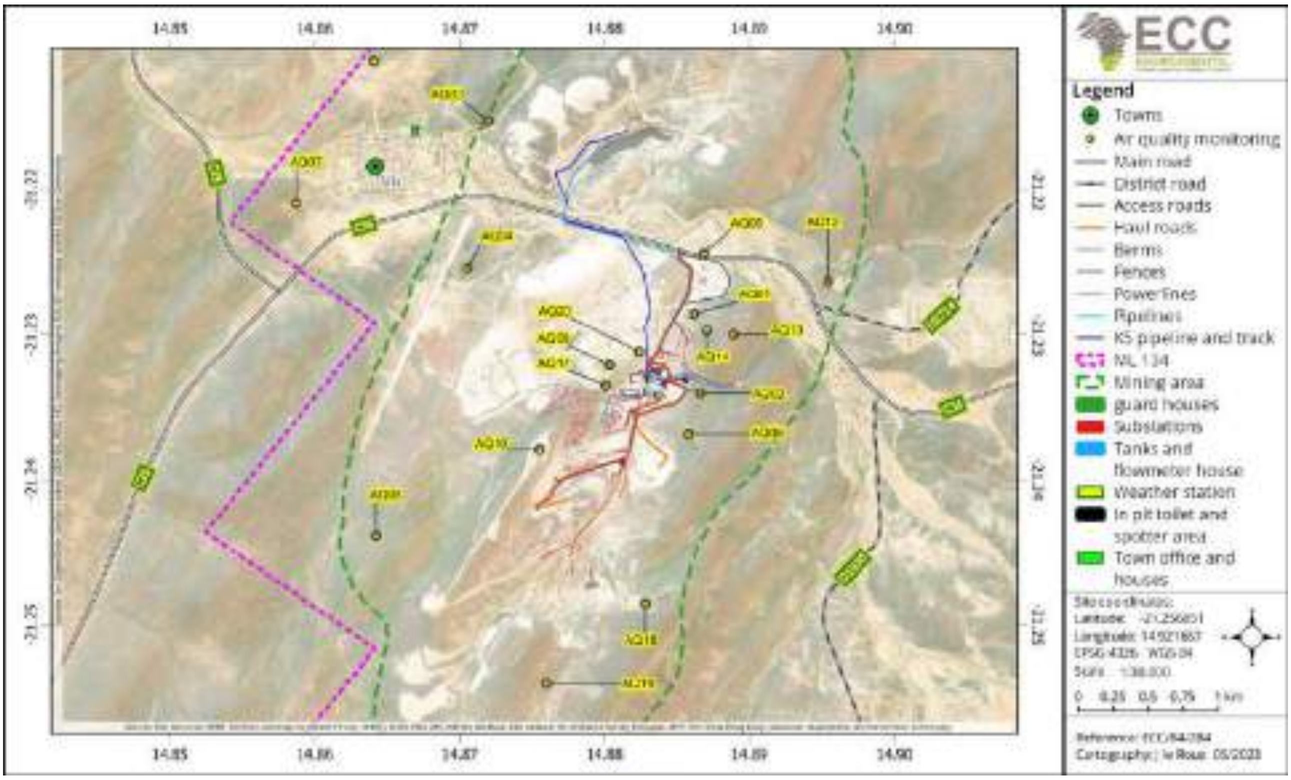


Figure 8: Domain 1 – Linear infrastructure with monitoring locations

Table 5 – Domain 1: Linear infrastructure domain schedule

<table>
<tr><th colspan="4">Domain 1 - Linear Infrastructure</th></tr>
<tr><td rowspan="2">Environmental risk of domain</td><td>Consequence</td><td>Likelihood</td><td>Risk</td></tr>
<tr><td>Insignificant 1</td><td>Likely 4</td><td>Moderate 4</td></tr>
<tr><td>Domain manager</td><td colspan="3">Technical Services Manager</td></tr>
<tr><td rowspan="2">Statutory requirements</td><td>Permit / Permit name</td><td colspan="2">Environmental permit conditions</td></tr>
<tr><td>Accessory works permit.

Water abstraction permit - Water abstraction permit for mining purposes should be obtained from Ministry of Agriculture Water and Forestry (if required)</td><td colspan="2">Permit renewal every 5 years or when significant changes occur.

Ensure the water abstraction volume is not exceeded.</td></tr>
<tr><td>Potential issues or impacts</td><td colspan="3">Water
- Water leaks from unchecked pipelines, leaking valves and flowmeters
- Groundwater contamination from hydrocarbon spills and leaks from hydraulic pipe bursts etc.
Air quality
- Dust generated from open roads
Noise
- Noise and nuisance factor to neighbouring communities from roads
- Impacts of noise on employees
Biodiversity
- Death of birds from power line collisions
- Wildlife injury from users of roads
- Vegetation damage from road users not using demarcated roads
Social
- Potential traffic issues during the construction and operational phases
- Water ponding creating mosquito breeding areas in dis-used borrow pits
- Nuisance dust or noise impacting neighbours
- Poor visual amenity for the site from dis-used borrow pits</td></tr>
<tr><td>Targets</td><td colspan="3">- Zero community complaints relating to dust or noise
- Dis-used roads and tracks are rehabilitated within 6 months of being deemed uneconomical or viable for future use
- Water loss prevented as much as possible</td></tr>
</table>

<table>
<tr><th colspan="6">Domain 1 - Linear Infrastructure</th></tr>
<tr><td>Operational management measures</td><td colspan="5">To minimise the effects the above-mentioned impacts may have on the environment and community, the domain manager will ensure the following measures are implemented:
- Maintain pipelines to ensure no water is lost through pipeline breaks and failures
- Ensure a leak detection system is in place on the water abstraction pipeline
- Ensure all flowmeters are operational through a daily/weekly check and if not operational abstraction is stopped until the flowmeter is replaced.
- Contractor management will be in place to ensure heavy delivery vehicles are kept in good mechanical condition to minimise noise associated with their operation and to prevent hydrocarbon spills.
- Open roads within the ML are managed using suitable dust suppression measures to prevent visible dust leaving the site.
- Speed limited are enforced on site to reduce dust and prevent collisions
- Existing tracks should always be used to prevent biodiversity loss
- Where death of birds due to power line collisions is reported suitable preventative measures such as bird deterrents will be placed on overhead lines by suitably qualified high voltage electrician.
- Minimising individual vehicle engine, transmission, and body noise/vibration by implementing a preventative maintenance program.
- Provide large visible road signage indicating the presence of heavy vehicle traffic at least 500 m before, on either side of the mine site access road.
- The needs of pedestrians should be taken into consideration in the planning and design of the access to the proposed site, as well as the design of the road infrastructure.
- Install streetlighting at the C36 turnoff to the mine entrance as a safety measure, and
- Install speed reduction signage (80km/hr) at least a kilometre away from the C36 turnoff to the mine entrance on either side of the turnoff.</td></tr>
<tr><td rowspan="2">Environmental pollution control measures (PCM)</td><td>PCM risk score</td><td colspan="2">Function and performance</td><td colspan="2">Maintenance frequency</td></tr>
<tr><td>Water truck
Low 3</td><td colspan="2">Used on a daily basis during the dry season to wet ground to reduce dust</td><td colspan="2">Monthly maintenance as per planned maintenance schedule</td></tr>
<tr><td rowspan="3">Environmental monitoring</td><td colspan="5">Environmental Monitoring</td></tr>
<tr><td>Site code</td><td>Name</td><td>Monitoring purpose</td><td>Frequency</td><td>Threshold</td></tr>
<tr><td>Air quality - Depositional dust monitoring</td><td>As shown in the domain map</td><td>Monitoring dust impacts on sensitive receptors</td><td>Monthly</td><td>600 mg/m²/day</td></tr>
</table>

Domain 1 - Linear Infrastructure					
	Abstraction volumes - Flowmeter readings	Site flow meters on abstraction points	Required to report the monthly abstraction volumes to DWA.	Monthly	As per permit conditions.
	Groundwater levels	As shown in the domain map	Required to monitoring aquifer groundwater levels	Monthly	NA
	Groundwater quality	As shown in the domain map	To monitor the change and trends in groundwater quality for the site	Quarterly	As per permit conditions
Environmental reporting	Domain manager to report to appointed ECO (monthly) - Any flowmeter leaks or breakages on a weekly basis. Appointed ECO to report to domain manager (monthly) - Complaints from neighbours to be directed to community relations manager in accordance with the grievance procedure. - Any complaints made from neighbours regrading noise from operations will be reported in the monthly report. The reports are to include a description of actions taken and response times. - Any biodiversity loss including bird collisions with powerlines and wildlife death.				
Environmental Inspection	**Daily**	**Weekly**	**Monthly**	**Other**	
	NA	NA	NA	NA	
Supporting Documents	Environmental monitoring plan Appendix A Domain sign off Appendix B				

DOMAIN 2 – OPEN PIT AND MINING AREAS

The mining methods utilised will consist of conventional drilling and blasting with the initial mining area focusing on exposed ore zones located within the old/existing mining footprint as well as new pegmatite outcrops. Two pits have been identified on ML 134, where mining activities are planned; namely the V1 and V2 pits as shown in Figure 9 and set out in Table 6.

This domain schedule includes all infrastructure and activities within the operational control of the domain outlined and mapped below:

- Open pits, and
- Mine offices and change house.

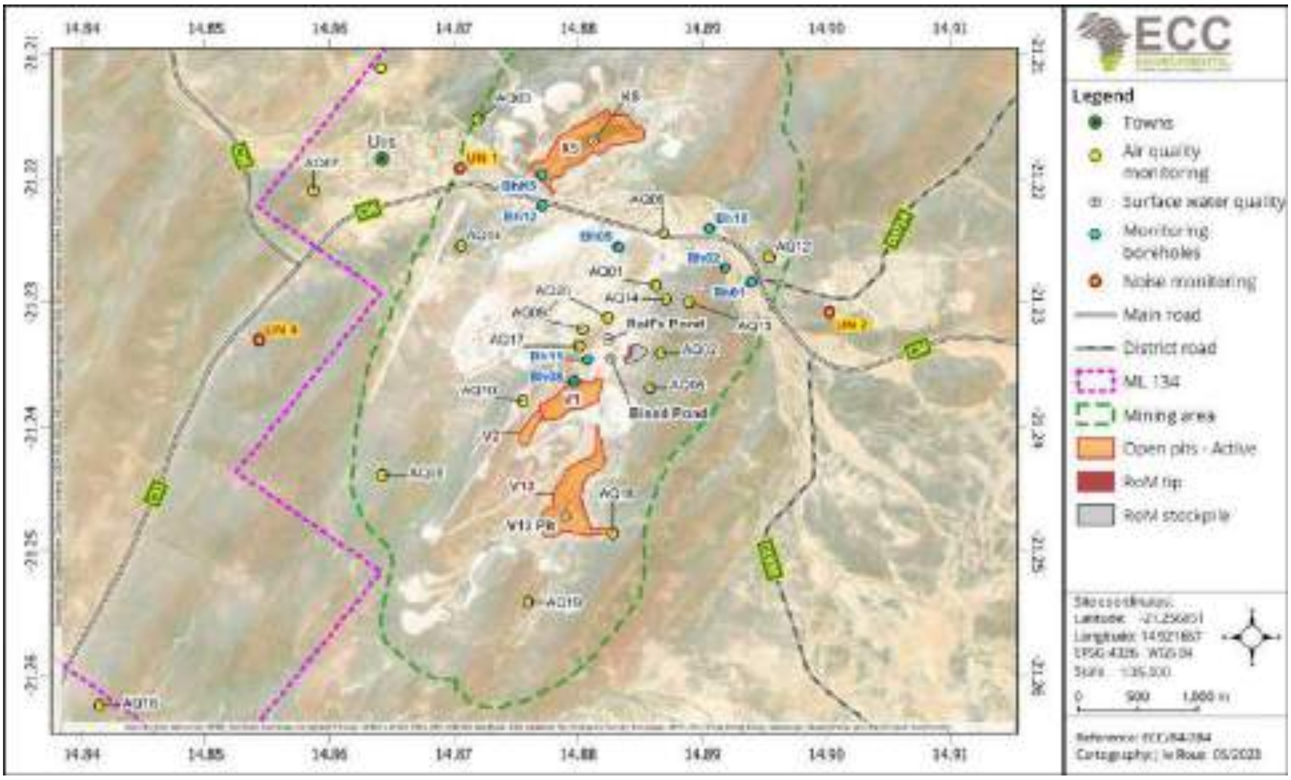


Figure 9: Domain 2 – Open pits and mining areas with monitoring locations

Table 6 – Domain 2: Open pit and mining areas domain schedule

Domain 2 - Open pit and mining areas			
Environmental risk of domain	**Consequence**	**Likelihood**	**Risk**
	Moderate 3	Likely 4	High 12
Domain manager	Technical Services Manager		
Statutory requirements	**Permit / Permit name**	**Environmental permit conditions**	
	A. Environmental Clearance Certificate (ECC)	A. Compliance to this OEMP	
	B. ML 134, ML 133, ML 129 Mining Licences	B. A mine closure plan will be in place and the mining operation will work towards concurrent mine closure through progressive rehabilitation. Integrate progressive rehab into the operational mining plan	
	C. Water abstraction permit - Water abstraction permit for mining purposes should be obtained from Ministry of Agriculture Water and Forestry (if required)	C. Ensure the water abstraction volume is not exceeded	
	D. Accessory works permit	D. Renewed every 5 years or when material change occurs.	
Potential issues or impacts	**Water** - Increase levels of nutrients and potential contamination of groundwater from excessive explosive use due to incorrect charging - Potential hydrocarbon contamination of groundwater from heavy equipment failures or spills, or incorrect servicing procedures - Decreased groundwater level around the site that impact from mine dewatering boreholes that may affect the groundwater levels in neighbouring boreholes - Impacts to the catchment area due to stormwater diversions incorrectly installed or water diverted away from the catchment - Contamination of an aquifer by the rebounding water table of potentially polluted water in the open pit workings after closure. - Potential for inrush into the open pit mine workings during development and operations - Over-abstraction for mining and processing activities **Air quality** - Dust generated from blasting activities			

Domain 2 - Open pit and mining areas	
	- Dust generated from drilling, hauling, loading and tipping of material **Biodiversity** - Excessive land clearing outside of approved areas - Fish farming can potentially be negatively affected by blasting and vibrations - Death and injury to wildlife from heavy equipment using haul roads or falling into pit - Disturbance and stress to wildlife from blasting vibration and noise **Social** - Noise to neighbours from mining activities including blasting and vibrations - Nuisance dust to neighbours from mining activities - Selective mining and poor resource stewardship - Potential structural damage to Borehole 8 and power line/pylon structures within the pit area due to ground vibrations from the minimum (69kg) explosive charges used - Potential structural damage to Borehole 8 and 11 and power line/pylon structures within the pit area due to ground vibrations from the maximum (207 kg)
Targets	- Zero complaints from neighbours relating to mining activities including blasting, dust or noise - Maintain abstraction of water at a rate as stipulated in abstraction permit - Ensure that production is not affected from accumulation of water in the open pits through the use of ad hoc dewatering of rain water - Technical Services Manager to report to the mining department in advance of potentially acid forming (PAF) mining so material can be handled correctly.
Operational management measures	To minimise the effects the above-mentioned impacts may have on the environment and community, the domain manager will ensure the following measures are implemented: - Ensure correct charging and use of explosive at all times in accordance site procedures - Ensure equipment is made available for servicing to prevent equipment-associated impacts (spills, noise etc.) - Ensure mining area complies with the mining plan and does not exceed the permitted area (i.e. prevent excessive clearing) - Ensure the roads are wet to prevent dust - Ensure existing roads and tracks are used as far as reasonably practical, and

Domain 2 - Open pit and mining areas	
	- Ensure the most effective and efficient blast pattern and explosive are used to limit the noise and vibration impacts to neighbours and wildlife. - Bulk fuel facilities to be kept adjacent to the mine site at a location with sealed surfaces and a spill collection sump; and - Refuelling of drills and equipment working at the pit wall faces will be done in a controlled manner following standard open pit refuelling procedures. - Fuel bowsers are to have drip trays for each refuelling event. - Ensure known structures, and water bearing features are mapped and surveyed and are incorporated into the mine plans and programmes; - Ensure monitoring systems are in place to detect potential inflows; and - Ensure the dewatering plan is followed and monitoring and reporting on the dewatering plan is undertaken. - The mine design may allow for the groundwater level to be intersected. The mine will act as a sink of potentially contaminated water from various sources, including the rebounding water table in the open pit workings; - Consider using the water for irrigation after closure (investigate viability) - Ensure the dewatering plan is followed and monitoring and reporting on the dewatering plan is undertaken; - Ensure all operations are undertaken in accordance with the mine and site water management plans; - Ensure all water bearing features are mapped and included in survey plans; - Ensure emergency response procedures are in place in the event of an inrush; and - Ensure adequate pumping capacity with backup pumps as critical spares are kept on site. - Do blast design that considers the actual blasting, and the ground vibration levels to be adhered too. - Only apply electronic initiation systems to facilitate single hole firing. - Do design for smaller diameter blast holes that will use fewer explosives per blast hole. - Relocate the POI / acquire the POI of concern – mined owned. - Blast designs should always minimise air emissions and noise, and control fly rock and vibration. - Blasthole liners and emulsion explosives should be used in wet holes. - Blast areas should be restricted to authorised personnel only.

<table>
<tr><th colspan="7">Domain 2 - Open pit and mining areas</th></tr>
<tr><td></td><td colspan="6">- Remain within specified occupational health and safety noise limits.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.</td></tr>
<tr><td rowspan="2">Environmental pollution control measures (PCM)</td><td>PCM risk score</td><td colspan="3">Function and performance</td><td colspan="2">Maintenance frequency</td></tr>
<tr><td>Water cart
Moderate 8</td><td colspan="3">Used on a daily basis to wet roads and stockpiles to reduce dust</td><td colspan="2">Monthly maintenance as per planned maintenance schedule</td></tr>
<tr><td rowspan="6">Environmental Monitoring</td><td>Site Code</td><td>Name</td><td colspan="2">Monitoring purpose</td><td>Frequency</td><td>Threshold</td></tr>
<tr><td>Noise – Ambient Noise</td><td>As shown on domain map</td><td colspan="2">Noise impacts on receptors</td><td>Annual</td><td>45 dB daytime
35 dB night time</td></tr>
<tr><td>Air quality - Depositional dust monitoring</td><td>As shown in the domain map</td><td colspan="2">Monitoring dust impacts on sensitive receptors</td><td>Monthly</td><td>600 mg/m^2/day</td></tr>
<tr><td>Groundwater levels</td><td>As shown in the domain map</td><td colspan="2">Required to monitoring aquifer groundwater levels</td><td>Monthly</td><td>NA</td></tr>
<tr><td>Groundwater quality</td><td>As shown in the domain map</td><td colspan="2">To monitor the change and trends in groundwater quality for the site</td><td>Quarterly</td><td>As per permit conditions</td></tr>
<tr><td>Vibration monitoring</td><td>As require</td><td colspan="2">To measure impact of mine blasting on community</td><td>Annually</td><td>NA</td></tr>
<tr><td>Environmental reporting</td><td colspan="6">Domain manager to report to appointed ECO (monthly)
- Volume of waste removed to waste rock dump
- Volume of ore mined
Appointed ECO to report to domain manager (monthly)
- Appointed ECO to report to the domain manager water quality results and levels monthly.
- Appointed ECO to interpret results and signatures relevant to the open pit i.e. nutrients, sulphides, hydrocarbons etc.) and report these to the domain manager against trigger values.
- Report air quality results to the domain manager, and</td></tr>
</table>

Domain 2 - Open pit and mining areas				
	- Volume of water abstracted from boreholes (flow meter readings)			
Environmental inspection/s	**Daily**	**Weekly**	**Monthly**	**Other**
	NA	Domain manager to complete	To be inspected by domain manager and appointed ECO	Annual compliance audit
Supporting documents	- Domain sign off Appendix B			

DOMAIN 3 – CO-DISPOSAL FACILITY AND WASTE ROCK DUMPS

The schedule includes all infrastructure and activities within the operational control of the domain outlined and mapped below:

- Hauling and dumping of mineral waste rock/material from the open pit;
- Co-disposal facility;
- Landform sloping and design; and
- Bulldozing and levelling of waste rock.

The existing waste rock dump will be used during mining operations as shown in Figure 10 and set out in Table 7. Mineral waste from the open pit mine is placed on the waste rock dump at a suitable angle which allows for future rehabilitation.

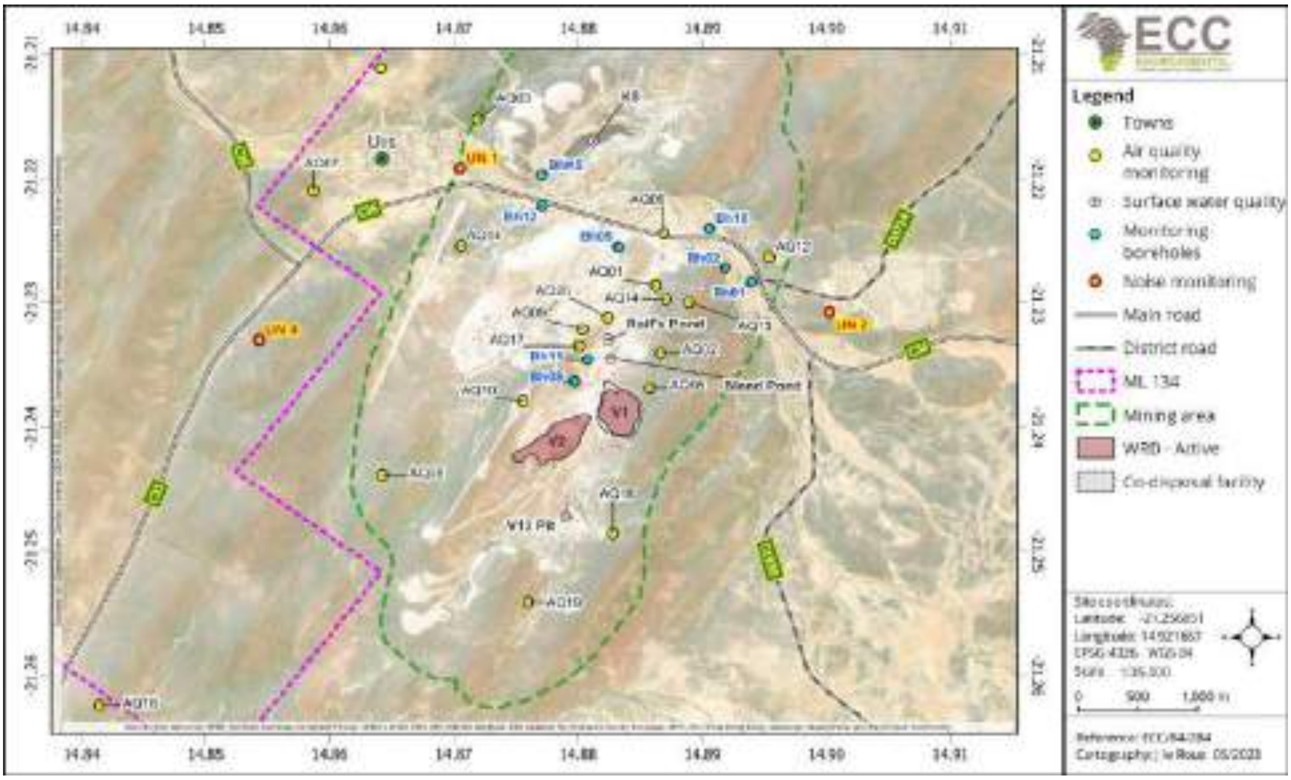


Figure 10: Domain 3 – Co-disposal facility and waste rock dumps with monitoring locations

The mining department is responsible for:

- Shaping the landform to comply with the mine design and the sites rehabilitation design requirements, and
- To ensure slopes are provided to the remediation specification as determined by the appointed ECO.

The technical services team in conjunction with the mining department are responsible for managing Potentially Acid Forming (PAF) waste. A proactive approach to PAF identification should be in place on the site.

The mine surveyors are responsible for ensuring that all PAF cells are identified and clearly included in the site plans for future use and consideration in the mine closure plan.

Table 7 – Domain 3: Co-disposal facility and waste rock dump domain schedule

<table>
<tr><th colspan="5">Domain 3 – Co-disposal facility and waste rock dump</th></tr>
<tr><td rowspan="2">Environmental risk of domain</td><td colspan="2">Consequence</td><td>Likelihood</td><td>Risk</td></tr>
<tr><td colspan="2">Major 4</td><td>Possible 3</td><td>High 12</td></tr>
<tr><td>Domain manager</td><td colspan="4">Technical Services Manager</td></tr>
<tr><td rowspan="2">Statutory requirements</td><td colspan="2">Permit / Permit name</td><td colspan="2">Environmental permit conditions</td></tr>
<tr><td colspan="2">In the event that new waste rock dump site needs to be established:

Where practical and required obtained a land clearing permit from the Ministry of Agriculture, Water and Forestry (MAWF) (Only valid for 3 months therefore must be applied for in advance of clearing works)</td><td colspan="2">Stipulated on permit. General conditions may include;
Number of protected trees to be removed, area cleared and surveyed, photos and use of resources cleared e.g. rehabilitation</td></tr>
<tr><td>Potential issues or impacts</td><td colspan="4">Water
- Potential for groundwater and surface water contamination from acid rock drainage (ARD)
Air Quality
- Dust generated from the truck movements on dump, hauling, loading and dumping
- Dust generated off unrehabilitated waste surfaces
- Dust generated from mobile crusher activities
Biodiversity
- Excessive clearing of vegetation for waste dump footprint
- Barrier to wildlife movement
- Loss of habitat
Social
- Nuisance noise and dust</td></tr>
<tr><td>Targets</td><td colspan="4">- Zero noise and dust complaints from neighbouring community
- 100% encapsulation of PAF material
- No clearing for the waste dump footprint without land clearing permits where recovery of topsoil or substrate material for rehabilitation is possible (10 days notices to be given)</td></tr>
</table>

Domain 3 – Co-disposal facility and waste rock dump	
	- Air quality monitoring reflects that the waste dump running surfaces have been kept moist with a 90% compliance commitment applied to the dust thresholds
Operational management measures	To minimise the effects the above-mentioned impacts may have on the environment and community, the domain manager will ensure the following measures are implemented: - A robust monitoring system is in place to predict and prevent ARD from mineral waste. - In the event PAF is identified, the SOP for PAF is triggered and PAF material is encapsulated, surveyed, and signed off according to the procedure. - Land clearing permits are applied from the appointed ECO in advance. The domain manager should ensure that the Land Clearing permit process is triggered at the mine planning stage and therefore must include environmental consideration for future works, this is important in areas where recovery of topsoil or substrate material for rehabilitation is possible. - Ensure a proactive approach to weather monitoring and when high winds are predicted, ensure an operational water cart is deployed to the waste dump to prevent excess dust being generated off the running surface of the waste dump. - Implement measures to reduce noise from the waste dump if monitoring/community feedback detects noise breaches (especially at night) from tipping or dumping activities. This might include a night-time tipping location that is below the highest level of the waste dump, so the dump can act as a noise barrier for neighbouring properties. - Ensure the mining plan includes provisions for rehabilitation and that the mining schedule is adhered to prevent visual impacts from an unrehabilitated waste dumps.

Environmental pollution control measures (PCM)	**PCM risk score**	**Function and performance**	**Maintenance frequency**
	Water cart Moderate 8	Water down surfaces to prevent dust	As per PMS
	ARD SOP Moderate 8	Used to monitor mineral waste for potentially acid forming material	Reviewed annually

Environmental Monitoring	**Site code**	**Name**	**Monitoring purpose**	**Frequency**	**Threshold**
	Acid rock drainage (ARD)	ARD monitoring	Visual monitoring around dumps after rains for ARD evidence	Within 24 – 48 hours rainfall	If field pH is <5 pH send sample to laboratory

<table>
<tr><th colspan="6">Domain 3 – Co-disposal facility and waste rock dump</th></tr>
<tr><td rowspan="5"></td><td rowspan="4">Water</td><td>Surface water sample to be taken at the toe of dump</td><td>Impacts of waste dump site on water quality in the area</td><td>Within 24 – 48 hours rainfall</td><td rowspan="4">Appendix A</td></tr>
<tr><td>As shown on domain map</td><td>Impacts on surface water quality</td><td>Monthly or when present</td></tr>
<tr><td>Groundwater levels</td><td>Impacts on groundwater from abstraction</td><td>Monthly</td></tr>
<tr><td>Groundwater quality - monitoring boreholes</td><td>Impacts on ground water quality</td><td>Quarterly</td></tr>
<tr><td>Deposition al dust</td><td>As shown on domain map</td><td>Impacts of dust from waste dumps on receptors</td><td>Monthly</td><td>600 mg/m^2/day</td></tr>
<tr><td>Environmental reporting</td><td colspan="5">Domain manager to report to appointed ECO (monthly)
- Volume of PAF material identified and survey locations if applicable.
- Any areas that required vegetation removal for the month ahead.
Appointed ECO to report to domain manager
- Notify domain manager in advance when high winds are predicated (daily).
- Notify domain manager if monitoring detects contamination from waste dump (monthly).</td></tr>
</table>

Environmental inspection/s	**Daily**	**Weekly**	**Monthly**	**Other**
	On shift geologist to inspect waste mined in the pit prior to dumping to confirm no evidence of PAF material	Domain manager to complete a weekly inspection of the domain	Domain manager and appointed ECO to complete	Bi-annual compliance audit
Supporting documents	Waste rock dump inspection form, Domain sign off Appendix B, Land clearing permit Appendix G.			

DOMAIN 4 –PROCESSING PLANT

The Uis Tin Mine site's trial processing plant shown in Figure 11 and set out in Table 8 improved design to process up to 120 TPH of concentrate.

- ROM
- Crusher
- Bulk sample processing facility
- Clean water channel, stormwater management system
- Sewerage, settling and water return ponds
- Water abstraction boreholes and management thereof

Figure 11: Domain 4 - Processing plant with monitoring locations

Table 8 – Domain 4: Process plant domain schedule

<table>
<tr><th colspan="4">Domain 4 – Process plant</th></tr>
<tr><td rowspan="2">Environmental risk of domain</td><td>Consequence</td><td>Likelihood</td><td>Risk</td></tr>
<tr><td>Moderate 4</td><td>Possible 3</td><td>High 12</td></tr>
<tr><td>Domain manager</td><td colspan="3">Processing Manager supported by the Engineering Manager</td></tr>
<tr><td rowspan="2">Statutory requirements</td><td colspan="2">Permit / Permit name</td><td>Environmental permit conditions</td></tr>
<tr><td colspan="2">Water abstraction permit</td><td>Nil</td></tr>
<tr><td>Potential issues or impacts</td><td colspan="3">Water
- Contamination of soil and water from plant and equipment
- Contamination from spillage of process material from pipeline breaks / failures
- Chemical spills from reagent mixing
- Sediment loading of surface water from uncontrolled surface discharge of open pit mine wastewater
- The potential failure of containment dams that hold mine site contact water (open pit mine dewatering water)
- Over-abstraction for mining and processing activities
- Groundwater cone of depression from potential cumulative abstractions
Air quality
- Dust generated from process areas
- Release of chemical gases from process operations
- Dust generated from ore falling onto stockpiles from height
Biodiversity
- Fauna deaths from drowning in ponds
- Fauna deaths from chemical ingestion
- Light pollution at night disorientating birds and bats
- Further reduction in the water table could affect deep rooted tree survival during droughts
- Clearing of vegetation during the expansion of the pilot plant
- Potential Impacts on biodiversity and migratory patterns of fauna
Social
- Noise from processing operations
- Light pollution at night
- Nuisance dust to neighbours</td></tr>
<tr><td>Targets</td><td colspan="3">- Zero process spills from the plant
- Zero noise or dust complaints from processing activities</td></tr>
<tr><td>Operational management measures</td><td colspan="3">To minimise the effects the above-mentioned impacts may have on the environment and community, the domain manager will ensure the following measures are implemented:</td></tr>
</table>

Domain 4 – Process plant	
	- Ensure wastewater produced from open pit mining activities is sent to the processing plant for reuse; and - If the volume of water is too large and cannot be handled by the processing plant for reuse, ensure an adequately sized sedimentation pond is constructed for handling the wastewater from the open pit mining operations. Reuse of the water back into the open pit mine can be investigated during operations for water quality. - Ensure all process bunds are kept empty and free of rainwater or process material - Ensure correct chemical use and clean-up procedures are in place and followed; - Ensure chemical spills are cleaned up within the open pit; and - In the event of heavy rainfall prevent spills from entering the dewatering system that would be transferred to the surface. - Ensure water storage facilities are constructed adequately and have the capacity to hold the volume of water to be pumped from the open pit workings and from run-on water to the site and facilities. - Ensure plant is maintained according to PMS - Ensure that pipes and flanges are contained within a bund - Ensure mixing of reagents is conducted according to site procedures - All lined ponds must have fauna egress mats at required intervals and not more than 50m apart - Ensure water bodies that could contain chemical that could poison fauna or birds are either; - Fitted with bird deterrents; or - Water body is of such a quality that mass fatalities do not occur - Ensure lighting towers and light fittings are pointing downwards - By checking for cracks in lining, vegetation growing in pond or green areas around water facilitates. - Integrate the groundwater outcomes into the site water balance to assist with the efficient management of water resources on site and identify and minimise water losses from the system; - Implement the monitoring, operational and maintenance requirements as outlined in the Water Management Plan - Locate or drill alternative boreholes to replace the existing boreholes if yields cannot be improved or maintained or to supplement water supply during borehole maintenance periods (after the K5 pit has been drained) - Schedule borehole maintenance every 2 years unless the monitoring data (yield vs drawdown) indicates more frequent cleaning is required; - Establish a covered water storage area nearby to the plant which contains water storage tanks with a minimum capacity of 1 week (~2700 m^3) which can provide an emergency water source to the plant; - Andrada will need to amend their permitted abstraction volume to account for the required 18 m^3/hr (127 440 m^3/a) required by the plant for the Phase 1 Stage II expansion;

<table>
<tr><th colspan="4">Domain 4 – Process plant</th></tr>
<tr><td></td><td colspan="3">- Locate third-party groundwater users within a 10 km radius of the mine wellfields and confirm their current abstraction requirements and planned future abstraction requirements;
- In the event that bulk dewatering is required to augment processing requirements, plan the dewatering of the K5 pit well in advance so the dewatered volumes can be used to meet the plant requirements instead of being discharged to the environment.
- The water quality requirements of the plant will therefore need to be defined as soon as possible or the establishment of a water treatment plant could be considered;
- The numerical model must be recalibrated every 2 (two) years to incorporate the latest monitoring data as well as any changes to the water supply network or plant yield requirements. The model will be an asset to Andrada to assess any changes which could affect the water supply for the Project;
- The numerical model can be refined in future updates to simulate climate change responses to the expected rainfall volumes over the life of mine. The IPCC report indicates that drought events in Southern Africa (caused by the El Nino oscillation) are predicted to become more frequent and intense, which could affect the recharge potential to aquifers in the region.
- Monitoring groundwater levels and physiological stress levels in trees to assess any correlation;
- Mapping trees that might be at risk using the cone of depression maps; and
- Determine feasibility for the rescue of these trees and carry out relocation if viable.
- Ensure internal land clearing permits are applied for prior to land clearing and through this process the environmental team has the opportunity to recover or rescue plants of significance or plants that can be used for progressive rehabilitation. Permits obtained from Directorate of Forestry;
- Minimal vegetation clearing and earthworks; and
- Basic vegetation clearing principles and species ID sheets.
- Avoid development and infrastructure in sensitive areas to minimise the negative effect on the local environment, especially unique features serving as habitat to various vertebrate fauna species;
- Remove (e.g., capture) unique fauna and sensitive fauna, before commencing with the development activities, as well as during the operational phase, and or species serendipitously located during this period and relocate to a less affected site in the immediate area; and
- Prevent domestic pets – e.g., cats and dogs – accompanying the workers to site
- All night lighting where possible should be directed downwards to reduce the impact on nocturnal bird movements; and
- Use lighting that is less likely to attract insects at night.</td></tr>
<tr><td>Environmental pollution</td><td>PCM Risk Score</td><td>Function and performance</td><td>Maintenance frequency</td></tr>
</table>

<table>
<tr><th colspan="6">Domain 4 – Process plant</th></tr>
<tr><td>control measures (PCM)</td><td colspan="2">Process Plant inspection Moderate 6</td><td colspan="2">Visual inspection to detect major spills or leaks from the Plant</td><td>Daily inspection</td></tr>
<tr><td rowspan="5">Environmental monitoring</td><td>Site code</td><td>Name</td><td>Monitoring purpose</td><td>Frequency</td><td>Threshold</td></tr>
<tr><td>Air quality - Depositional dust monitoring</td><td>As shown in the domain map</td><td>Monitoring dust impacts on sensitive receptors</td><td>Monthly</td><td>600 mg/m^2/day</td></tr>
<tr><td>Noise – Ambient</td><td>As shown on domain map</td><td>To determine impacts of noise on nearest sensitive receptor</td><td>Monthly</td><td>45 dB Day time
35 dB Night time</td></tr>
<tr><td>Groundwater levels</td><td>As shown in the domain map</td><td>Required to monitoring aquifer groundwater levels</td><td>Monthly</td><td>NA</td></tr>
<tr><td>Groundwater quality</td><td>As shown in the domain map</td><td>To monitor the change and trends in groundwater quality for the site</td><td>Quarterly</td><td>As per permit conditions</td></tr>
<tr><td>Environmental reporting</td><td colspan="5">Domain manager to report to appointed ECO (monthly)
- Report monthly process water volumes to the appointed ECO
- Report an wildlife fatalities straight away to the appointed ECO
Appointed ECO to report to domain manager (monthly)
- ECO to report to the domain manager process water quality results monthly.
- ECO to interpret results and signatures relevant to the process plant i.e. heavy metals, etc. and report these to the DM against trigger values.</td></tr>
<tr><td rowspan="2">Environmental inspection/s</td><td colspan="2">Daily</td><td>Weekly</td><td>Monthly</td><td>Other</td></tr>
<tr><td colspan="2">Shift supervisor to complete the daily visual inspection</td><td>Domain manager to complete a weekly process plant and tailings line inspection</td><td>Domain manager and appointed ECO to complete monthly inspection</td><td>Bi-annual compliance audit</td></tr>
<tr><td>Supporting Documents</td><td colspan="5">Area inspection form,
Domain sign off Appendix B, and
Spill prevention and management.</td></tr>
</table>

DOMAIN 5 – WORKSHOPS

Almost all items of light and heavy equipment are serviced and maintained on site at the Uis Tin Mine Engineering workshops.
This domain schedule includes all infrastructure and activities within the operational control of the domain outlined and mapped below Figure 12 and set out in Table 9:

- Heavy and light vehicle workshops;
- Contractors workshops;
- Wash bay;
- Excavator pad;
- Offices;
- Tyre workshop; and
- All mobile maintenance activities for infield emergency repairs, maintenance or servicing of equipment.

Figure 12: Domain 5 – Workshops with monitoring locations

Table 9 – Domain 5: Workshops domain schedule

<table>
<tr><th colspan="7">Domain 5 – Workshops</th></tr>
<tr><td rowspan="2">Environmental risk of domain</td><td colspan="2">Consequence</td><td colspan="2">Likelihood</td><td colspan="2">Risk</td></tr>
<tr><td colspan="2">Minor 2</td><td colspan="2">Possible 3</td><td colspan="2">Moderate 6</td></tr>
<tr><td>Domain manager</td><td colspan="6">Technical Services Manager supported by Engineering Manager</td></tr>
<tr><td rowspan="2">statutory requirements</td><td colspan="3">Permit / Permit name</td><td colspan="3">Environmental permit conditions</td></tr>
<tr><td colspan="3">A. Nil</td><td colspan="3">A. Nil</td></tr>
<tr><td>Potential issues or impacts</td><td colspan="6">Water
- Contamination of soil and water from plant and equipment,
- Contamination from spillage of chemicals and hydrocarbons,
- Chemical spills from infield refuelling, reloading or mechanical breakdowns,
- Contamination to surface water from a poorly functioning / designed wash bay.
Air quality
- Dust generated from workshop loading bays,
- Increased PM emissions from poorly maintained equipment.
Biodiversity
- Fauna deaths from drowning in ponds,
- Fauna deaths from chemical ingestion,
- Light pollution at night disorientating birds and bats.
Social
- Noise from workshop operations especially at night</td></tr>
<tr><td>Targets</td><td colspan="6">- Ensure the wash bay is operational and compliant at all time,
- Ensure all chemicals are stored correctly and bunded at all times.</td></tr>
<tr><td>Operational management measures</td><td colspan="6">To minimise the effects of the above mentioned impacts pose to the environment and community, the domain manager will ensure the following measures are implemented:
- Ensure that pipes and flanges are contained within a bund,
- Ensure all staff are trained on how to respond to chemical spills and emergencies,
- Ensure all bunds are kept empty and free of rainwater,
- Ensure plant is maintained according to PMS,
- Ensure staff report leaking pipes, joins or flanges to prevent failure,
- Ensure refuelling, handling of chemicals, oils and greases is conducted according to specific site procedures,
- Ensure that all waste oil tanks are pumped out at 80% full capacity.</td></tr>
<tr><td rowspan="6">Environmental pollution control measures (PCM)</td><td colspan="2">PCM risk score</td><td colspan="2">Function and performance</td><td colspan="2">Maintenance frequency</td></tr>
<tr><td colspan="2">Wash bay
LOW 3</td><td colspan="2">The final collection point for the domains oily and contaminated wastewater.</td><td colspan="2">Daily</td></tr>
<tr><td colspan="6">Noise</td></tr>
<tr><td>Site Code</td><td>Name</td><td colspan="2">Monitoring Purpose</td><td>Frequency</td><td>Threshold</td></tr>
<tr><td>Noise - Ambient</td><td>N 01</td><td colspan="2">Impacts of noise on Uis</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="6">Domain 5 – Workshops</th></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>N 02</td><td>Impacts of noise on nearest receptors (The Uis Village Council and NamClay bricks)</td><td rowspan="2"></td><td rowspan="2">45 dB daytime
35 dB night time</td></tr>
<tr><td>N 03</td><td>Impacts of noise on settlement</td></tr>
<tr><td></td><td>Surface water – wash bay functionality</td><td>TBD</td><td>A surface water monitoring point to determine the effectiveness of the wash bay hydrocarbon treatment prior to water being used elsewhere on site.</td><td>Monthly</td><td>As per permit conditions</td></tr>
<tr><td>Environmental reporting</td><td colspan="5">Domain manager to report to appointed ECO (monthly)
- Quantities of fuels and oils used.
Appointed ECO to report to domain manager (monthly)
- Water quality results relating to the wash bay.</td></tr>
<tr><td rowspan="2">Environmental inspection/s</td><td>Daily</td><td colspan="2">Weekly</td><td>Monthly</td><td>Other</td></tr>
<tr><td>To be completed by the shift supervisor</td><td colspan="2">To be completed by the foreman with the shift supervisor</td><td>To be completed with the appointed ECO and the HOD</td><td>Bi-annual compliance audit</td></tr>
<tr><td>Supporting documents</td><td colspan="5">- Area inspection form,
- Domain sign off Appendix B, and
- Spill prevention and management.</td></tr>
</table>

DOMAIN 6 – FUEL DEPOT

UTMC will be constructing a fuel depot on site, which will supply fuel for all activities on site as required.

This domain schedule includes all infrastructure and activities within the operational control of the domain outlined and mapped below Figure 13 and set out in Table 10:

- Fuel storage.

Figure 13: Domain 6 - Fuel depot with monitoring locations

Table 10 - Domain 6: Fuel depot domain schedule

Domain 6 – Fuel depot			
Environmental risk of domain	**Consequence** Catastrophic (5)	**Likelihood** Rare (1)	**Risk** High 5
Domain manager	Supply Chain Officer and General Manager		
Statutory requirements	**Permit / Permit Name** A. Nil	**Environmental permit conditions** A. Nil	
Potential issues or impacts	**Water** - Potential contamination from breach of fuel containment **Biodiversity** - Spills can lead to detrimental damage to soil **Social** - Fire hazard		
Targets	- Ensure the safe handling, transportation and containment of fuel		
Operational management measures	To minimise the effects the above-mentioned impacts may have on the environment and community, the domain manager will ensure the following measures are implemented: - Fencing off fuel depot to avoid unauthorised entrance, - All hydrocarbons must be stored in a bund at all times, - The bund needs to hold 110% of the largest unit stored in the bund, - Small bunded containments need to be sheltered from the rain, - Storage areas require adequate ventilation, - Storage area to be kept clean and tidy and free of combustibles, - Equipment at the depot must be kept in a good state, - In the event of a spill, hazardous material may be generated. This material must be disposed in a suitable manner. - Leak proof drums for the disposal of oils and grease must be placed at a suitable location where such hazardous material can likely be generated, - Ensure equipment that is clearing vegetation is free of weeds and seeds prior to clearing vegetation, - Any leakages and spills must be reported to the domain manager. **Fuel deliveries and dispensing** - Do not leave area unattended when refuelling, the use of a Deadman switch should be investigated and installed on site to reduce potentials of spill during refuelling - Turn off all vehicles while refueling, - No smoking should be allowed in the fuel depot area especially during fuel handling. **Tank, pump and pipelines** - Any suspected leaks and spills should be reported to the domain manager,		

<table>
<tr><th colspan="2">Domain 6 – Fuel depot</th></tr>
<tr><td></td><td>- Any leaks from tanks or pipelines must be checked and attended to immediately, the leak should be isolated, and the general area should be treated with an absorbing agent immediately.

Fire prevention and control

- Ensure fire extinguishers are kept in close proximity and attended to regularly,
- Training should be provided in the use of the appropriate firefighting equipment,
- Smoking should be prohibited in the vicinity of flammable substances.</td></tr>
<tr><td>Environmental pollution control measures (PCM)</td><td><table>
<tr><th>PCM Risk Score</th><th>Function and performance</th><th>Maintenance frequency</th></tr>
<tr><td>Emergency response plan Low 3</td><td>To set out guidelines for emergency response</td><td>Nil</td></tr>
</table></td></tr>
<tr><td>Environment Monitoring</td><td>Biodiversity<table>
<tr><th>Site Code</th><th>Name</th><th>Monitoring purpose</th><th>Frequency</th><th>Threshold</th></tr>
<tr><td></td><td>Visual</td><td>Inspect tanks for leakages and any breach of containment within this domain.</td><td>Daily</td><td>NA</td></tr>
</table></td></tr>
<tr><td>Environmental reporting</td><td>Domain manager to report to appointed ECO (monthly)
- Nil
Appointed ECO to report to domain manager (monthly)
- Nil</td></tr>
<tr><td>Environmental inspection/s</td><td><table>
<tr><th>Daily</th><th>Weekly</th><th>Monthly</th><th>Other</th></tr>
<tr><td>To be completed by the shift supervisor</td><td>Inspection by domain manager</td><td>To be completed with the appointed ECO</td><td>6 monthly</td></tr>
</table></td></tr>
<tr><td>Supporting documents</td><td>- Land clearing permit Appendix G,
- Area inspection form, and
- Domain sign off Appendix B.</td></tr>
</table>

DOMAIN 7 – SALVAGE YARD AND NON-MINERALISED WASTE FACILITY

The first options for the handling of non-mineralised waste is to reduce, re-use and recycle. A landfill facility is to be constructed on the mine site for the event that the first options are not practically feasible. The location of the on-site landfill is still to be decided and although there is currently a landfill on-site, this site will require significant work to reach an acceptable standard. The landfill is to be classified as a non-hazardous landfill therefore each cell is earthen lined. The landfill site should be fenced to avoid windblown litter and to control access to the landfill site.

Uis Tin Mine should consider other alternatives for the non-mineralised waste facility, such as using the municipal waste site (which is poorly managed) or use on-site waste removal options such as waste incineration.

This domain schedule includes all infrastructure and activities within the operational control of the domain outlined and mapped below Figure 14 and set out in Table 11:

- Proposed landfill;
- Salvage yard; and
- An on site designed landfill for non mineralised waste.

Figure 14: Domain 7 - Salvage yard and non-mineral waste facility

Table 11 – Domain 7: Salvage yard and non-mineral waste facility domain schedule

<table>
<tr><td colspan="6">Domain 7- Salvage yard and non-mineral waste facility (landfill and recycling site)</td></tr>
<tr><td rowspan="2">Environmental risk of domain</td><td colspan="2">Consequence</td><td colspan="2">Likelihood</td><td>Risk</td></tr>
<tr><td colspan="2">Minor 2</td><td colspan="2">Possible 3</td><td>Moderate 6</td></tr>
<tr><td>Domain manager</td><td colspan="5">Engineering Manager</td></tr>
<tr><td rowspan="2">Statutory requirements</td><td colspan="3">Permit / Permit name</td><td colspan="2">Environmental permit conditions</td></tr>
<tr><td colspan="3">A. Environmental Clearance Certificate</td><td colspan="2">A. Compliance with the EIA that supports the clearance certificate</td></tr>
<tr><td>Potential issues or impacts</td><td colspan="5">Water
- Contamination to groundwater from incorrect disposal of waste in the landfill,
- Contamination from uncleared drums or containers from the chemicals used in the operation arriving at the waste site.
Air quality
- Dust from landfill operations
Biodiversity
- Loss of topsoil and remediation material,
- Potential poaching incidents from landfill operators,
- Injury to wildlife from scavenging in the landfill site.
Social
- Nuisance odour from landfill</td></tr>
<tr><td>Targets</td><td colspan="5">- Demonstrate an increase in the throughput of recycled materials annually,
- Demonstrate a reduction in volumes of waste going into landfill annually.</td></tr>
<tr><td>Operational management measures</td><td colspan="5">To minimise the effects the above mentioned impacts may have on the environment and community, the domain manager will ensure the following measures are implemented:
- A vegetation clearing permit is obtained through the appointed ECO prior to land clearing activities where recovery of topsoil or substrate material for rehabilitation is possible,
- Vegetation is cleared and stockpiled for rehabilitation,
- Quality control process are in place to prevent hazardous materials entering the landfill site,
- Ensure training and awareness is in place with all operators to prevent contaminated drums or containers arriving on the landfill site.</td></tr>
<tr><td rowspan="2">Environmental pollution control measures (PCM)</td><td>PCM risk score</td><td colspan="3">Function and performance</td><td>Maintenance frequency</td></tr>
<tr><td>Fencing of landfill
LOW 3</td><td colspan="3">Improves containment of waste to landfill site</td><td>Weekly</td></tr>
<tr><td rowspan="2">Environment monitoring</td><td colspan="5">Water quality</td></tr>
<tr><td>Site Code</td><td>Name</td><td>Monitoring purpose</td><td>Frequency</td><td>Threshold</td></tr>
</table>

<table>
<tr><th colspan="9">Domain 7- Salvage yard and non-mineral waste facility (landfill and recycling site)</th></tr>
<tr><td rowspan="4"></td><td colspan="2">Ground- and surface water quality</td><td>To be confirmed upon suitable landfill location selection</td><td colspan="2">To detect contamination from landfill site</td><td colspan="2"></td><td>Appendix A</td></tr>
<tr><td colspan="8">Air quality</td></tr>
<tr><td colspan="2">Site code</td><td>Name</td><td colspan="2">Monitoring purpose</td><td colspan="2">Frequency</td><td>Threshold</td></tr>
<tr><td colspan="2">Depositional dust</td><td>To be confirmed upon suitable landfill location selection</td><td colspan="2">Air quality from the landfill</td><td colspan="2">Monthly</td><td>600 mg/m²/day</td></tr>
<tr><td>Environmental reporting</td><td colspan="8">Domain manager to report to appointed ECO (monthly)
- Volumes of waste sent to landfill,
- Volumes of recycled materials.
Appointed ECO to report to domain manager (monthly)
- Results from water quality monitoring relating to potential landfill contamination,
- Results from air quality monitoring relating to the landfill.</td></tr>
<tr><td rowspan="2">Environmental inspection/s</td><td>Daily</td><td colspan="2">Weekly</td><td colspan="2">Monthly</td><td colspan="3">Other</td></tr>
<tr><td>Landfill operator supervisor to inspect the facility</td><td colspan="2">Inspection by domain manager</td><td colspan="2">Appointed ECO and domain manager to complete</td><td colspan="3">Bi-annual compliance audit</td></tr>
<tr><td>Supporting documents</td><td colspan="8">- Area inspection form
- Domain sign off Appendix B</td></tr>
</table>

DOMAIN 8 – OLD CONTRACTORS CAMP

A contractor’s camp is located on the site that was erected only for the construction phase.

This domain has since closed and has been rehabilitated. It is now subject to the formal closure and rehabilitation process in accordance with the sites mine closure plan; the domain has been retained in the OEMP for completion purposes until closure is complete and signed off.

This domain schedule includes all infrastructure and activities within the operational control of the construction camp or any further construction camps and mapped below Figure 15 and set out in Table 12:

- Accommodation facilitates for construction employees.

Figure 15: Domain 8 – Old contractors camp with monitoring locations

Table 12 – Domain 8: Old contractors camp - domain schedule

Domain 8 – Old contractors camp					
Environmental risk of domain	**Consequence**	**Likelihood**	**Risk**		
	Minor B	Unlikely 2	**Low 5**		
Domain manager	Technical Services Manager				
Statutory requirements	**Permit / Permit name**	**Environmental permit conditions**			
	A. Nil	A. Nil			
Potential issues or impacts	**Water** - Contamination from canteen or mess area from fats oils and grease entering the wastewater system. **Air quality** - Nil **Biodiversity** - Poaching risk from employees staying on site, - Potential for fire as a result of unauthorised fires being lit in the camp. **Social** - Reputation damage with neighbouring farmers from poaching incidents.				
Targets	- Zero incidents relating to poaching from camp				
Operational management measures	To minimise the effects the above-mentioned impacts may have on the environment and community, the domain manager will ensure the following measures are implemented: - Ensure the fence around the main camp is maintained, - Ensure the fat trap is cleaned our monthly by approved contractor, - Ensure all contractors are educated and aware of camp rules including poaching and fires.				
Environmental pollution control measures (PCM)	**PCM risk score**	**Function and performance**	**Maintenance frequency**		
	Canteen fat trap **Low 3**	Intercepts fats, oils and grease to prevent contamination to wastewater stream	Monthly		
	BIODIVERSITY				
	Site code	**Name**	**Monitoring purpose**	**Frequency**	**Threshold**
	Contractor's camp	Campsite	Monitoring for potential poaching/snares	Weekly	Zero
Environmental reporting	**Domain manager to report to appointed ECO (monthly)** - Nil **Appointed ECO to report to domain manager (monthly)** - Nil				
Environmental inspection/s	**Daily**	**Weekly**	**Monthly**	**Other**	
	Nil	Nil	Appointed ECO with domain manager to complete	Annual audit of compliance	

Domain 8 – Old contractors camp	
Supporting documents	- Area inspection form, - Domain sign off Appendix B.

POTENTIAL FUTURE DOMAIN – BIO-REMEDIATION SITE

When a hydrocarbon spill occurs on site, the spill is assessed, and a suitable remediation plan is actioned depending on the location and site of the spill. When the spill cannot be transported to the bioremediation site it is remediated in situ. A suitable location for the bio-remediation site is yet to be selected, in the event of hydrocarbon spills the material is collected and transported to the bioremediation site for treatment.

This domain schedule and set out in Table 13 includes all infrastructure and activities within the operational control of the domain outlined and mapped below:

- Bio-remediation facility/cells

Table 13 – Potential future domain: Bio-remediation site domain schedule

Potential future domain – Bio-remediation site			
Environmental risk of domain	**Consequence**	**Likelihood**	**Risk**
	Major 4	Possible 3	High 12
Domain manager	Technical Services Manager supported by the General Manager		
Statutory requirements	**Permit / Permit name**	**Environmental permit conditions**	
	Nil	Nil	
Potential issues or impacts	**Water** - Contamination to groundwater from leaking liners in the facility - Contamination to surface water from overfilling of cells and contamination to surrounding areas **Air quality** - Dust generated from open and dry cells **Biodiversity** - Wildlife trapped in cells **Social** - NA		
Targets	Remediate available soil in a timely manner		
Operational management measures	To minimise the effects the above-mentioned impacts may have on the environment and community, the domain manager will ensure the following measures are implemented: - All cells are constructed according to the specifications - The facility is managed according to the site procedures		
Environmental pollution control measures (PCM)	PCM risk score	Function and performance	Maintenance frequency
	Nil	Nil	Nil
Environmental reporting	Domain manager to report to appointed ECO (monthly) - Volume of material received into the facility each month		

<table>
<tr><th colspan="5">Potential future domain – Bio-remediation site</th></tr>
<tr><td></td><td colspan="4">- Volume of material treated each month
- Volume of material produced for rehab

Appointed ECO to report to domain manager (monthly)

- Water quality results as applicable</td></tr>
<tr><td rowspan="2">Environmental inspection/s</td><td>Daily</td><td>Weekly</td><td>Monthly</td><td>Other</td></tr>
<tr><td>Nil</td><td>Domain manager</td><td>Environmental officer with domain manager</td><td>Bi-annual compliance audit</td></tr>
<tr><td>Supporting documents</td><td colspan="4">Area inspection form,
Domain sign off Appendix B, and
Spill prevention and management.</td></tr>
</table>

APPENDIX PAGES

APPENDIX A – ENVIRONMENTAL MONITORING PROGRAMME AND TRIGGER VALUES BASED ON NAMIBIAN STANDARDS

Table 14 - Uis tin mine monitoring plan

Type	Rationale	Monitoring area / site description / details	Frequency	Phase (construction, operations, decommissioning, or all)	Parameters	Quality control point
Air quality -Dust fallout collection	Potential impacts on air quality can arise from mine development and operations. Air quality monitoring is done to monitor the potential impacts on surrounding communities. Potential to generate dust during access track development, blasting and use of haul roads.	Sites surrounding the mine – in line with predominant wind direction. The co-ordinates for the selected sites are: **AQ 01** (21'13'44''S 14'52'57''E) **AQ 02** (21'14'10''S 14'53'8''E) **AQ 03** (21'12'54''S 14'52'20E) **AQ 04** (21'13'24''S 14'52'11''E) **AQ 05** (21'13''32''S 14'53'13E)	Prior to mine operations to determine the baseline air quality - Monthly At the onset of mining operations – Five (5) samplers exchanged monthly for 12 months	All	Total Suspended Particulates (TSP)	Yes Yes
Air quality-Passive sampling	Equipment used during operations generates SO_2	The co-ordinates for the selected sites are: **AQ 01** (21'13'44''S 14'52'57''E) **AQ 02** (21'14'10''S 14'53'8''E) **AQ 03** (21'12'54''S 14'52'20E) **AQ 04** (21'13'24''S 14'52'11''E)	Five samplers; cartridges are exchanged every month for 12 months	Operations	Sulphur Dioxide (SO_2)	Yes

Type	Rationale	Monitoring area / site description / details	Frequency	Phase (construction, operations, decommissioning, or all)	Parameters	Quality control point
		AQ 05 (21'13''32''S 14'53'13E)				
Air quality- Minivol	Dust generating activities such as road construction, mining activities such as drilling and blasting, excavation and land clearing Wind erosion on tailings dumps.	The co-ordinates for the selected sites are: **AQ 01** (21'13'44''S 14'52'57''E) **AQ 02** (21'14'10''S 14'53'8''E) **AQ 03** (21'12'54''S 14'52'20''E) **AQ 04** (21'13'24''S 14'52'11''E) **AQ 05** (21'13''32''S 14'53'13E)	Three-day cycle for one month	Operations	PM_{10} and $PM_{2.5}$	Yes
Water quality	To monitor the water quality (both surface and ground water). Monitoring prior to the onset of mining operations- to determine baseline. Monitoring after mining commences to determine impacts of mining operations on water quality.	Existing open pits, the co-ordinates are as follows: **Surface Water Sites** **South Pit - WQ 01** (21°14'43.90"S 14°52'45.33"E) **North Pit - WQ 02** (21°13'7.30"S 14°52'42.60"E) **Groundwater Sites** To be determined / confirmed with groundwater specialist	Annually	All	pH Metals	Yes
Noise	Noise monitoring to determine impact of development on	Specific locations selected to conduct noise monitoring: **N 01**	During the construction phase of the mine – Quarterly	Prior to construction commencing and during construction	dB	No

Type	Rationale	Monitoring area / site description / details	Frequency	Phase (construction, operations, decommissioning, or all)	Parameters	Quality control point
	residents and surrounding areas	(21'13'24''S 14'52'11E) **N 02** (21'12'47"S 14'51'40E) **N 03** (21°13'37.32"S 14°53'40.93"E)	During the mine's operational phase – Annually			
Biodiversity	An LFA transect was to monitor the baseline diversity	**LFA site** (21'14'6"S 14'53'7"E)	Inspected Monthly		Visual and inspections	Yes

THRESHOLDS FOR AIR QUALITY

The Namibian Atmospheric Pollution Prevention Ordinance, No. 11 of 1976, does not make provision for any standards for individuals and institutions to comply to with regards to fall out dust. The South African National Dust Control Regulations (NDCR) state the limits in Table 15 for dustfall rates in residential and non- residential areas.

Table 15 - Allowable dustfall limits

RESTRICTION AREAS	DUSTFALL RATE (D) ($mg/m^2/day$), 30 -DAYS AVERAGE)	PERMITTED FREQUENCY OF EXCEEDING DUST FALL RATE
Residential area	D < 600	Two within a year, not sequential months
Non-residential area	D ≤ 1200	Two within a year, not sequential months

The most widely referenced international criteria are those published by the World Bank group (WB), World Health Organization (WHO), and the European Union (EU) as shown in Table 16. Additionally, South African legislation (the Air Quality Act No. 39 of 2004) stipulates air quality standards for the mining sector, which can be regarded as representative indicators to Namibia because of the similarity in social, environmental and economic features.

Table 16 - Standards / guidelines derived from the WB, WHO, EU and South African standards

POLLUTANT	AVERAGING PERIOD	WHO GUIDELINES ($\mu g/m^3$)	EU DIRECTIVES ($\mu g/m^3$)	SOUTH AFRICA STANDARDS NAAQS ($\mu g/m^3$)
Particulate matter PM10	1 year 24 hours	70 50 30 20 150 100 75 50	40 50	50 40 120 75
Particulate matter PM2.5	1 year 24 hours	35 25 15 10 75 50 37.5 25	25 -	25 20 15 65 40 25
Sulphur dioxide (SO_2)	1 year 24 hours 1 hour 10 minutes	- 125 50 20 - 500	20 125 350 -	50 125 350 500

POLLUTANT	AVERAGING PERIOD	WHO GUIDELINES (µg/m³)	EU DIRECTIVES (µg/m³)	SOUTH AFRICA STANDARDS NAAQS (µg/m³)
Carbon monoxide (CO)	1 hour	30 000	10 000	30 000
Nitrogen Dioxide (NO_2)	1 year 1 hour	40 200	40 200	40 200

THRESHOLDS FOR WATER QUALITY

It is required that all mine water in Namibia is adequately monitored and analysed to ensure compliance to regulatory standards, according to the obligatory industrial and domestic effluent discharge exemption permit under section 21(5) and 22(2) of the Water Act (Act 54 of 1956). Table 17 indicates the general standards for Article 21 Permits (effluents).

Table 17 - General standards for waste/effluent water discharge

DETERMINANTS	MAXIMUM ALLOWABLE LEVELS
Arsenic	0,5 mg/l as As
Biological Oxygen Demand (BOD)	no value given
Boron	1,0 mg/l as B
Chemical Oxygen Demand (COD)	75 mg / l as O
Chlorine, residual	0,1 mg/l as Cl2
Chromium, hexavalent	50 µg/l as Cr (VI)
Chromium, total	500 µg/l as Cr
Copper	1,0 mg/l as Cu
Oxygen, dissolved (DO)	at least 75% saturation
Detergents, Surfactants, Tensides	0,5 mg/l as MBAS
Fats, Oil & Grease (FOG)	2,5 mg/l (gravimetric method)
Fluoride	1,0 mg/l as F
Free & Saline Ammonia	10 mg/l as N
Lead	1,0 mg/l as Pb
Oxygen, Absorbed (OA)	10 mg / l as O
pH	5,5 – 9,5
Phenolic Compounds	100 µg/l as phenol
Phosphate	1,0 mg/l as P
Sodium	not more than 90 mg/l Na more than influent
Sulphide	1,0 mg/l as S
Temperature	35°C
Total Dissolved Solids (TDS)	not more than 500 mg /l more than influent
Total Suspended Solids (TSS)	25 mg/l
Typical faecal Coli.	no typical coli should be counted per 100 ml
Zinc	5,0 mg/l as Zn

THRESHOLD FOR NOISE

The South African Noise level Criteria, SANS 10103: 2003 (SABS 0103) is frequently used in Namibia to determine the maximum allowable ambient noise levels Table 18 which should not be exceeded.

Table 18- Recommended allowable ambient sound (rating) levels for various land use type districts

Type of District	**Maximum Allowable Ambient Noise Levels L_{eq} (Hourly) in dB (A)**					
	Outdoors			**Indoors with Windows Closed**		
	Day- night ($L_{R, dn}$)	Daytime ($L_{Req, d}$)	Night – time ($L_{Req, n}$)	Day -night ($L_{R, dn}$)	Daytime ($L_{R, d}$)	Night – time ($L_{R, n}$)
RESIDENTIAL DISTRICTS						
a) Rural Districts	45	45	35	35	35	25
b) Suburban districts (little road traffic)	50	50	40	40	40	40
c) Urban districts	55	55	45	45	45	35
NON- RESIDENTIAL DISTRICTS						
d) Urban districts (some workshops, business premises and main roads)	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50
Note: Residential buildings such as dormitories, hotel accommodation, residences, etc. should only be allowed in non- residential districts on condition that the calculated anticipated indoor maximum equivalent continuous rating levels ($L_{Req, T}$)						

APPENDIX B – DOMAIN SIGN OFF AND CERTIFICATION

The picture can't be displayed.

APPENDIX C – GRIEVANCE SUBMISSION FORM

GRIEVANCE SUBMISSION FORM

Reference Number:

Date:

D	D	M	M	Y	Y

Submitted at:

Windhoek Representative Office	
Uis Office	
Site Office	

Please mark applicable box with an X:

I want to raise my grievance anonymously	
My identity may only be disclosed with my consent	

First or given name:

Last name/Surname:

How would you prefer to be contacted?

By Post	
By Telephone/Mobile	
By E-mail	

Postal Address:

Landline number: ( )

Mobile number:

Preferred language for feedback communication:

Description of Incident or Grievance (What happened? Where? Who was involved? What is the result?)

Please mark the appropriate block with an X:

It was a once-off incident		Date: / /
It happened more than once		How many times?.......
It is an ongoing problem		

What would you like AfriTin to do to resolve this problem?

Respondent Signature:

AfriTin Representative Signature:

APPENDIX D – DOMAIN CHECKLISTS

APPENDIX E – WEED AND SEED CLEARANCE CERTIFICATE

EMP SUPPORT FORMS AND TOOLS

WEED AND SEED CLEARANCE CERTIFICATE

SECTION 1 – PROJECT MANAGER TO COMPLETE (AT LEAST 2 DAYS PRIORTO EQUIPMENT ARRIVING)

Project Manager or responsible person bringing equipment to site:

Name:		Department:	
Site:		Equipment Arrival Date:	

Details of the owner of the equipment:

Equipment owner:		Company Name:	
Equipment type:		Equipment ID:	
Date Equipment was washed:		Inspected By:	
Where was the equipment last used:			

SECTION 2 - ENVIRONMENTAL CONTROL OFFICER TO COMPLETE PRIOR TO ANY GROUND WORKS COMMENCING

Inspection area	Requirements	Compliance		
		Yes	No	NA
Body works	Free of all soil and vegetation?			
Bumpers	Hollow sections and attachment points free of dirt			
Tyres	Free of all soil and vegetation			
Dual Wheels	Free of all soil and vegetation			
Canopy	Free of all soil and vegetation			
Radiator	Free of all soil and vegetation – specifically look for seed heads			
Interior	Free of soil and vegetation – specifically look for seed heads in upholstery and under mats			
Storage compartments	Free of all soil and vegetation			
Jack and tool kit	Check tool roll and spare wheel are clean			
Racks and bull bars	Free of all soil and vegetation			
Ropes/ Straps/ Cages	Free of all soil and vegetation? Carefully check Velcro and tensioning devices			
Tracks	Carefully check tracks are clean of soil and vegetation			

APPENDIX F – ENVIRONMENTAL IMPROVEMENT PLAN

AFRITIN MINING	HSE Improvement Plan	Document Number:	
		Page:	1 of 1
		Issue Date:	February 12,2019
		Revision:	1.0

Department:	**Date Created:**	
Created By:	**C-Safe number:**	
Environmental Improvement Program		
Objective:		
Target: **1.** **2.**		
Key Performance Indicator: **1.**		
Target Date:	**Accountable Person:**	**Signature:**
Significant Risk Register Number/s:		

Task	Target/KPI (#)	Responsible Person	Completion Date	C-Safe No.	Signature
1.					
2.					
3.					
4.					
5.					
6. .					
7.					
8.					
9.					
10.					

Notes:

Approval : ________________________________ Department Manager (signature over printed name)

Date :_________________________________

Approval : ________________________________ General Manager (signature over printed name)

Date :_________________________________

Uncontrolled if Printed: Printed on: 12 February 2019; Review 2 Years after issue date

APPENDIX G – LAND CLEARING PERMIT

EMP SUPPORT FORMS AND TOOLS

INTERNAL LAND CLEARING CERTIFICATE

SECTION 1 – PROJECT MANAGER TO COMPLETE

Submit to the Project Environmental Officer 7 DAYS PRIOR to ground disturbing works

Site:			
Project Manager:		**Department:**	
Commencement date:		**Estimated completion date:**	
Size of area to clear:		**Date of application:**	
Map *(must be attached)* ❑	**Photos: Yes ❑ No ❑**	**Est. No. Trees to be removed**	
Equipment to be Used:		**Mining Licence Number:**	

Purpose of clearing

Map showing area to be cleared

APPENDIX H – STANDARD OPERATING PROCEDURE – WATER QUALITY MONITORING

APPENDIX I – STANDARD OPERATING PROCEDURE – AIR QUALITY MONITORING

APPENDIX J – STANDARD OPERATING PROCEDURE – AMBIENT NOISE MONITORING

APPENDIX K – SUPPORTING DOCUMENTS

EMERGENCY RESPONSE PLAN
AFRITIN UIS TIN MINE
February 2019

AFRITIN MINING

1.0 INTRODUCTION

The main objective of this procedure is to manage and contain the spill thereby minimizing adverse effects on the environment. The procedure is also intended to ensure the safety of site personnel and nearby community.

2.0 GENERAL PROCEDURES

If you recognize a hazardous spill:

- Move away from spill
- Alert others and restrict access to the spill area
- If the spill occurs indoor, close door and windows to control ventilation. Turn off fans, heaters, etc.
- Alert company specialists of situation.
- Do not attempt to contain material unless you are trained and equipped to do so
- Identify material only if this can be done safely
- Call emergency numbers
- Alert responding medical personnel (on site or outside of the site) if victim has been contaminated by toxic material.

3.0 SPECIFIC PROCEDURES

3.1 Hydrocarbon Spills

PROCEDURE:

- Supervisor will inspect and assess the spillage area.
- Supervisor will ensure all personnel near the area are notified of the spill occurrence and personnel involved in the leak clean up and repairs preparation have suitable protective clothing including. No special PPE is required but a dust mask is recommended.
- The source of the spill will be isolated to prevent the spill from becoming larger
- Spills should be cleaned up by means of absorption, which typically converts the liquid spill into a solid for easy clean up
- The spill material is then disposed – the disposal method is dependent on the extent and nature of the spill
- Report the spill to the Environmental Officer on site

3.2 Acid Spills

Acid spills should be neutralized first before being pumped to the tails hopper, as they can cause fumes if pumped directly to the tails hopper.

Personal Protective Equipment:

- Standard Site PPE
- Rubber gloves (full length)
- Mono-goggles/Face shield
- Yellow protective coat and pants (2x)
- Full length chemical apron (1x)
- Respirator (2x)

Procedures

Step	Action	Notes
1	Examine the size of the acid spill. If it is less than 50 liters then dilute with approximately 15minutes of hosing before pumping to the tails hopper	Do not hose directly into the acid
2	If spill is outside of bunded area attempt to contain spill with earthen containment If it is more than 50liters, notify your supervisor immediately before proceeding Sentry will be required	An investigation into the cause of the spill will be required Any spill outside a bunded area or the release of a hazardous gas must have an environmental incident report written up
3	Notify downwind personnel of spill and evacuate as necessary	Contact emergency number if necessary
4	Call for an assistant to help you with the task of neutralizing the spill. You must have two people present at all times in case of any incidents occurring	
5	Put on the required PPE.	A full-face respirator, pair of long gloves, yellow protective coat and pants, and full-length apron is required
6	With the use of the forklift, bring the pallet of soda ash (in the reagents shed) to the acid spill	
7	Estimate the size of the spill. Every 50L of acid will require a 25kg bag of soda ash to neutralize it	
8	The sentry must be wearing the required PPE as well and should stand back for the following steps (respirator can be hanging around your neck)	A full-face respirator, pair of long gloves and yellow protective coat and pants is required for the sentry
9	Carefully put the required amount of soda ash into an unaffected area. If this is not possible (i.e. the bund floor is totally covered in acid solution) carefully pour all of the required amount into a neat pile into a corner of the bund	The reaction between the acid and the soda ash is violent and bubbling will occur, this is just carbon dioxide gas forming and is not harmful, however it will cause the solution to splash around so make sure all due care is taken when adding the two together
10	Using a hose slowly pout water onto the pile of soda ash and gently mix it into the acid solution	Be careful not to splash acid solution on to yourself or others

Step	Action	Notes
11	Once all of the soda ash has been mixed into the acid solution, more water can be added to ensure it has been diluted as much as possible	
12	Start the sump pump to dispose of the neutralized acid. Hose out the bund to remove all traces of acid and soda ash	
13	Clean the chemical aprons thoroughly with water and dry it before placing it back in the green plastic bag	
14	Dispose of the red rubber gloves and issue new ones from the store, place them in the green plastic bag	
15	Issue soda ash from the store to replace the once used. There must be 10 bags of soda ash available at all times from the reagent shed	
16	Notify your supervisor that you have disposed of the acid spill and assist with the investigation if required. Have the supervisor declare the area safe	Incident report or environmental spill report must be submitted within 24hours of incident

Submitted to: Uis Tin Mining Company (Pty) Ltd
Attention: Mr Ephraim Tourob
4th Avenue East, Number 1, Uis
P O Box 30
Uis, Namibia

I&AP COMMENTS COMPILATION:

PUBLIC CONSULTATION FOR THE STAGE II EXPANSION OF THE PILOT TIN PROCESSING PLANT INCLUDING A BULK SAMPLE, SORTING AND TESTING FACILITY ON ML 134

PROJECT NUMBER: ECC-84-284-REP-18-D

REPORT VERSION: REV 01

DATE: 30 MAY 2023

Prepared by: ECC Environmental Compliance Consultancy

TITLE AND APPROVAL PAGE

Project Name:	Public consultation for the stage II expansion of the pilot tin processing plant including a bulk sample, sorting and testing facility on ML 134
Client Company Name:	Uis Tin Mining Company (Pty) Ltd
Client Representatives:	Mr Ephraim Tourob
Ministry Reference:	APP-002964
Authors:	Jessica Bezuidenhout
Status of Report:	Draft for public review
Project Number:	ECC-84-284-REP-18-D
Date of issue:	30 May 2023
Review Period	30 May – 15 June 2023

ENVIRONMENTAL COMPLIANCE CONSULTANCY CONTACT DETAILS:

We welcome any enquiries regarding this document and its content. Please contact:

Environmental Compliance Consultancy
PO Box 91193, Klein Windhoek, Namibia
Tel: +264 81 669 7608
Email: info@eccenvironmental.com

DISCLAIMER

The report has been prepared by Environmental Compliance Consultancy (Pty) Ltd (ECC) (Reg. No. 2022/0593) on behalf of the Proponent. Authored by ECC employees with no material interest in the report's outcome, ECC maintains independence from the Proponent and has no financial interest in the Project apart from fair remuneration for professional fees. Payment of fees is not contingent on the report's results or any government decision. ECC members or employees are not, and do not intend to be, employed by the Proponent, nor do they hold any shareholding in the Project. Personal views expressed by the writer may not reflect ECC or its client's views. The environmental report's information is based on the best available data and professional judgment at the time of writing. However, please note that environmental conditions can change rapidly, and the accuracy, completeness, or currency of the information cannot be guaranteed.

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
DMS	dense medium separation
EAP	environmental assessment practitioner
ECC	Environmental Compliance Consultancy
EIA	Environmental Impact Assessment
EMP	environmental management plan
ESIA	Environmental and Social Impact Assessment
I&APs	Interested and Affected Parties
MEFT	Ministry of Environment, Forestry and Tourism
ML	Mining Licence
UTM	Uis Tin Mining Company
TOR	terms of reference
tph	Tons per hour

1 SUMMARY OF FOCUS GROUP MEETING AND COMMENTS RECEIVED FROM I&APS

1.1 INTRODUCTION

Environmental Compliance Consultancy (ECC) has been engaged by Uis Tin Mining Company (Pty) Ltd (hereafter referred to as UTM), the Proponent, to conduct an Environmental Impact Assessment (EIA) in accordance with the Environmental Management Act, No. 7 of 2007 and its regulations of 2012, for which an application for an environmental clearance certificate will be submitted for the stage II expansion of their pilot tin processing plant on ML 134 within the Erongo Region, Namibia.

AfriTin Mining is a mining company with a portfolio of tin assets in Namibia and South Africa. Uis Tin Mining Company, the Namibian registered subsidiary, proposes to undertake mechanical and process flow upgrades to its existing tin extraction systems. The Project objectives are to increase production throughput by expanding the pilot tin processing plant on mining licence (ML) 134 located near Uis in the Erongo Region, Namibia. Uis can be accessed by the C36 road from Omaruru, the C35 from Henties Bay or the C35 from Khorixas.

The proposed Project upgrades to the current pilot plant's processing and supporting infrastructure will expand production from the current 80 tons per hour (tph) in stage 1 to 120 tph in Stage II. As part of this project the following upgrades will also be made upgrades to the dense medium separation (DMS) cyclone feed, inlet pressure system, and constant moisture control of feed material, etc.

1.2 FOCUS GROUP MEETING SUMMARY

The focus group meeting was facilitated by ECCs senior practitioner –with the assistance of the Environmental assessment practitioner (EAP) with the technical support of Mr Ralf Schommarz (previously mine manager) at UTMC. The welcoming and agenda of the meeting included an introduction to ECC as an independent environmental consulting company commissioned by the Proponent UTM as the environmental assessment practitioner (EAP) to conduct the environmental impact assessment for the Project as part of the environmental clearance certification application process for the proposed Project.

As part of the Project's introduction to the public, the following was outlined:

- Project location
- Baseline
- ESIA process and procedures

An explanation of the Project's current status was provided to the public. It was emphasized that the objective of the current public scoping meeting conducted in the early scoping phase is to engage all stakeholders and to identify further potential studies and assessments that may be required for inclusion in the environmental impact assessment of the Project.

The technical presentation by UTM then provided an overview of the proposed construction and operation of the processing plant as well as the overall Project:

The presentation from ECC covered a detailed description of the public consultation purpose and intentions as part of the environmental and social impact assessment (ESIA) process for the processing plant. At this stage, I&APs were encouraged and informed of the importance of raising any concerns and comments related to the proposed operations of the processing plant which are to be considered in the ESIA studies and submitted along with the application for an environmental clearance certificate to the competent authorities and MEFT for a record of decision.

The main components of the environmental assessment identified for consideration in the ESIA were discussed, aspects and concerns raised which will form an important part of the impact study for the proposed Project. The current phase involves and engages I&APs to develop target-specific Terms of References (TOR) for necessary specialist studies to address all identified concerns and potential impacts in the assessment report.

1.3 KEY FEEDBACK ON ISSUES OF CONCERN – FOCUS GROUP MEETING

The pool of comments received from all meetings held was provided by key stakeholders and representatives of the community. The I&APs provided useful and valuable input into the ESIA through points and comments raised during the various meetings. From the review of the recorded statements the key common theme/s of concern that was raised can be summarised as follows:

1.3.1 JOB CREATION AND SOCIAL UPLIFTMENT PROGRAMMES

The I&APs in attendance questioned as to whether or not this expansion of the mine would provide an opportunity for more jobs to be required and filled by locals from the Uis community. They also queried whether or not this expansion would allow for more social upliftment programmes in the community. They gave examples such as bursaries to be offered to the local schools' top students and local training opportunities, so that when the mine closes the local residents would have a better opportunity of sustaining themselves. Additionally, with the ever-rising municipality fees the residents need a source of income to afford these expenses. The EAP assured that this will be looked at as part of the ESIA and recommendations would be made to the Proponent to remedy the situation.

1.3.2 DUST

The I&APs also mentioned that there has also been an increasing problem with dust coming from the mine that they would like to be addressed. The EAP explained that there are various methods that the mine uses to keep dust pollution down, however that this would be revisited in the ESIA, and more mitigation and management measures would be recommended and implemented into the mine's environmental management plan (EMP).

2 ACKNOWLEDGEMENTS

In closing of the meeting ECC thanked all I&APs for their attendance and for providing valuable feedback during the focus group meeting. Through the public engagement process the Proponent and ECC have endeavoured to provide a platform to hear and address all relevant comments put forward by I&APs.

ECC further endorsed the fact that constructive feedback from I&APs results in a more robust and improved ESIA. This process results in a project that is understood by the community and I&APs. The I&AP's feedback will contribute to identifying the potential impacts to be assessed and concerns to be considered and addressed as the project progresses.

2.1 DETAILED COMMENTS AND RESPONSES FROM THE FOCUS GROUP MEETING

The official public consultation period began on the 8th of September 2021 and remained open until the 22nd of September 2022 for initial comments. These were received during the focus group meeting and via email which are to be included in the Scoping Report. These comments and their respective responses are included in the tables below.

Further comments were welcome after that date and the public consultation period will remain open for I&APs until the final assessment report for the project is ready for submission to the competent authorities.

Table 1 - Comments and feedback from the focus group meeting

19th October 2021 Uis Settlement Office, Boardroom		
Stakeholder name and details	**Comments/question received**	**Response/clarification**
Mr Amingo Control administrative officer of Uis town club	1. Assets of the previous mines were bought by Mr/Honneb, currently the regional council runs the town on which there are certain areas of land and waste caused by the previous mine which is in the vicinity of the town centre. 2. Who these belong to specifically the white sand and who to contact should the government want to make use of the sand. 3. Who the two ponds found close to their office and another one close to the mine belong to currently since they still have economic value. 4. With the re-opening of the mine, as a resident there are high hopes of employment creation and social upliftment of the town thus pleads that core focus during employment should be on the local residents of Uis so as to create a sense of belongingness and take pride in the mine re-opening	- We do not know unfortunately, but that would be a very important piece of information that could be included in the report so that, with all the baseline data you end up having an ownership map or strata of ownership. - The main message of our social sections would be about local and that would be a recommendation to you as a town, the company and the government to join forces and make that happen. The project expansion is early in the company's process that; they are using it to see how well it works before proceeding to the next step, but we could liaise with the company on that to see what is required.
Mr R. Tsibeb Erongo Red	With regards to the baseline assessment of rehabilitation, what is the plan in place to rehabilitate the area.	Unprocessed rocks that come out of a mine are usually stacked together with the fines that come out of processing which have little to no financial value. Currently, they are being disposed of by use

19th October 2021 Uis Settlement Office, Boardroom		
Stakeholder name and details	**Comments/question received**	**Response/clarification**
		of trucks and there is a top elevation that it will go to and in the end the area will be easier to grow any trees, grass or bushes. Also, we will recommend to the company that activities of that nature be included during mining operations to test out the feasibility of the rehabilitation initiative and it will be included in the report as well.
Mrs Julia Garises Tatamutsi Dev. Committee-Chairlady	1. During the end of mining activities, the lives of the town residents take a different turn whereby jobs are lost and even the town service providers increase their trading prices (such as the municipality bills). Can this be taken into consideration? 2. Will be any sponsorship opportunities from the mine introduced destined for top performing learners to further their studies.	– It is difficult because the town was doing well until the regional/town council decide that bills will be increased given the low number of people remaining in the town. So, jobs, training and capacity building are significant for residents to sustain themselves in one way or another. This will also be included in the report and since the project is still in its early stages, plans can be made taking the above-mentioned into account as was well communicated. – Noted
Unidentified I&AP	Asked why development projects do not employ a few people from the town of project origin and train them physically to do the work.	It is not always easy to do but given that this is a small project; it makes total sense

19th October 2021 Uis Settlement Office, Boardroom		
Stakeholder name and details	**Comments/question received**	**Response/clarification**
Unidentified I&AP	Emphasized the dust issue stating that the mine authority and proponent need to come together and discuss this as fugitive dust is a serious cause for concern for Uis inhabitants and those in nearby areas.	Noted
Helena Geingos Brandberg Primary School Principal	1. Asked if there are motivational programmes in place to introduce mining to the school-going learners at the 2 local schools that might trigger. their interest and may want to take up geology and mining-related courses in future and then come back to work in their hometown. 2. in future schools will be permitted to plan day trips and bring learners to see the mine.	– It would be great to introduce such programmes and this can be done on a few occasions for instance during career day at the schools. Suggestion acknowledged and notes take on that. – It is not easy to do a mine tour unless it is fully shut down. Mine activities are mainly underground and the main priority with such operations is safety of personnel
Unidentified I&AP	Are any measures in place to control the dust pollution and noise impacts as advancements in technology develop	From traffic, there is use of water trucks to control dust on site. There's also different kinds of salts and several others that can help pack the dust down, using water sprays at dusty points in the facility may work really well too. Recommending chemicals that may be seen as hazardous and toxic is not ideal in this regard, but there are several things that can be done to control that although it is quite hard since there is dust everywhere.

19th October 2021 Uis Settlement Office, Boardroom		
Stakeholder name and details	**Comments/question received**	**Response/clarification**
Unidentified I&AP	1. Why are there no more traffic cones used on the road leading to the site as a way of restricting vehicles from heading in that direction like they were used during the blasting stage. 2. Why there is no public communication for residents to take caution on the day of blasting and to keep their animals indoors too	– This will be discussed with the proponent to pool together ideas on what they plan to do regarding the above-mentioned. – Commented that, at the moment the road is not closed because there are no blasting activities taking place, the blasting site is also located far away from the road, and it is always kept locked for safety reasons
Unidentified I&AP	Asked how far the project expansion site is from the current area.	The main part of the expansion and the mining place is going to be where it has been in the past, the mining operations are relatively small thus, there is no need for frequent blasting to feed the plant, so the footprint is going to be equivalent to the previous one.

APPENDIX A – BID

APPENDIX B – STAKEHOLDER CONSULTATION ENGAGEMENT LETTER

+264 81 669 7608
info@eccenvironmental.com
www.eccenvironmental.com

RECEIVED BY OFFICIAL STAMP
Received by Name:
Date:
Signature:

REFERENCE: ECC-84-284-LET-08-A
8th September 2021

Dear Identified Stakeholder and or Potentially Interested Party:

RE: INVITATION TO A FOCUS GROUP MEETING FOR THE UIS TIN MINE EXPANSION STAGE II MINE PROJECT, UIS DISTRICT IN THE ERONGO REGION.

Environmental Compliance Consultancy (ECC) on behalf of our client Uis Tin Mining Company (Pty) Ltd would like to inform you of our intended, and upcoming, focus group meeting for the Uis Tin Mine Environmental and Social Impact Assessment. ECC is conducting the assessment in accordance with the Environmental Management Act, No. 7 of 2007, for which an application for an environmental clearance certificate will be submitted for the proposed expansion of mining and processing activities on ML 134 in the Erongo Region.

Uis Tin Mining Company (Pty) Ltd proposes several mechanical and process flow upgrades to components of the current pilot plant's processing and supporting infrastructure (i.e., upgrades to the Dense Medium Separation (DMS) 1 cyclone feed, inlet pressure system rates and constant moisture control within feed material, etc.) and therefore, an expected increase in the production rate from the current 80 Tons Per Hour (TPH) in stage 1 to 120 TPH in stage 2. To implement the proposed upgrades, various other supporting infrastructure on-site require an upgrade to be able to sustain and support the planned expansion project. The planned expansion will ensure a life of operations of 20 years.

This letter is to extend an invitation to you as an identified stakeholder and potentially Interested and Affected Party (I&AP) of the project and provide a communication channel with ECC. ECC wishes to invite you to attend the focus group meeting and

ENVIRONMENTAL COMPLIANCE CONSULTANCY CC
PO BOX 91193 WINDHOEK, NAMIBIA
MEMBERS: J L MOONEY & JS BEZUIDENHOUT
REGISTRATION NUMBER: CC/2013/11404

provide input to the environmental and social impact assessment (ESIA) as per the details below:

Focus Group Meeting:
Uis Settlement, Tuesday, **16th September 2021**
Meeting Address: Uis Settlement Office, opposite the NamClay factory entrance
Time: **10:00 AM.**

We kindly request that you RSVP by email to info@eccenvironmental.com or phone on 081 669 7608 and confirm your attendance for the focus group meeting.

In addition to the above meeting, Uis Tin Mining Company (Pty) Ltd is committed to engaging all affected stakeholders through planned, ongoing public participation in as required.

ECC values community input and participation in our projects and we look forward to working with you as the project develops. Should you require further information, please do not hesitate to contact us.

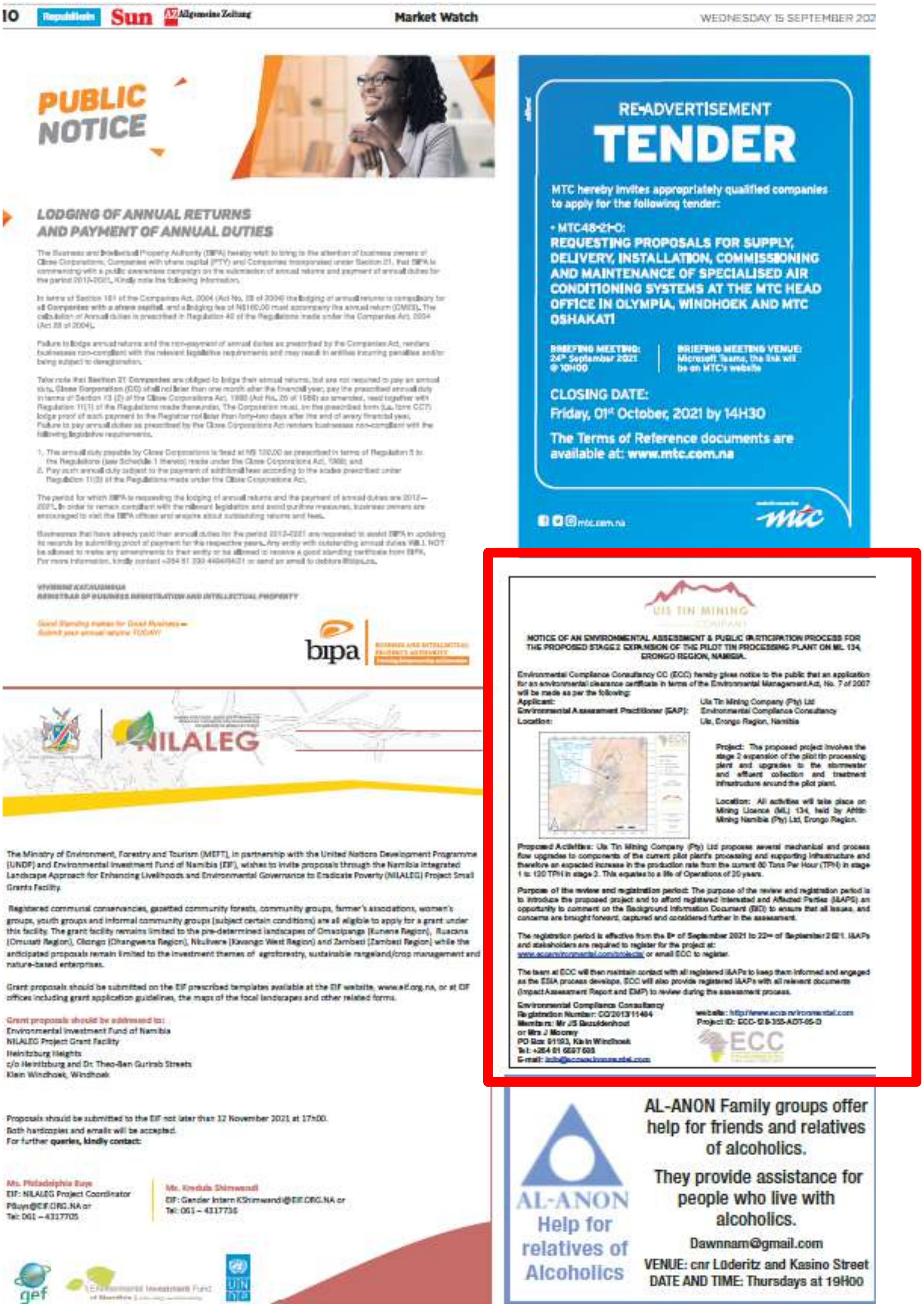
Yours sincerely,

Stephan Bezuidenhout
Environmental Compliance Consultancy
Contact: 081 669 7608
Email: stephan@eccenvironmental.com

Jessica Bezuidenhout Mooney
Environmental Compliance Consultancy
Contact: 081 669 7608
Email: jessica@eccenvironmental.com

ENVIRONMENTAL COMPLIANCE CONSULTANCY CC
PO BOX 91193 WINDHOEK, NAMIBIA
MEMBERS: J L MOONEY & JS BEZUIDENHOUT
REGISTRATION NUMBER: CC/2013/11404

APPENDIX C – ADVERTS PUBLISHED



10 Republikein Sun Allgemeine Zeitung Market Watch WEDNESDAY 15 SEPTEMBER 2021

PUBLIC NOTICE

LODGING OF ANNUAL RETURNS AND PAYMENT OF ANNUAL DUTIES

RE-ADVERTISEMENT

TENDER

MTC hereby invites appropriately qualified companies to apply for the following tender:

• MTC48-21-O:
REQUESTING PROPOSALS FOR SUPPLY, DELIVERY, INSTALLATION, COMMISSIONING AND MAINTENANCE OF SPECIALISED AIR CONDITIONING SYSTEMS AT THE MTC HEAD OFFICE IN OLYMPIA, WINDHOEK AND MTC OSHAKATI

BRIEFING MEETING: 24th September 2021 @ 10H00

BRIEFING MEETING VENUE: Microsoft Teams, the link will be on MTC's website

CLOSING DATE:
Friday, 01st October, 2021 by 14H30

The Terms of Reference documents are available at: www.mtc.com.na

mtc.com.na

mtc

UIS TIN MINING COMPANY

NOTICE OF AN ENVIRONMENTAL ASSESSMENT & PUBLIC PARTICIPATION PROCESS FOR THE PROPOSED STAGE 2 EXPANSION OF THE PILOT TIN PROCESSING PLANT ON ML 134, ERONGO REGION, NAMIBIA.

Environmental Compliance Consultancy CC (ECC) hereby gives notice to the public that an application for an environmental clearance certificate in terms of the Environmental Management Act, No. 7 of 2007 will be made as per the following:

Applicant: Uis Tin Mining Company (Pty) Ltd
Environmental Assessment Practitioner (EAP): Environmental Compliance Consultancy
Location: Uis, Erongo Region, Namibia

Project: The proposed project involves the stage 2 expansion of the pilot tin processing plant and upgrades to the stormwater and effluent collection and treatment infrastructure around the pilot plant.

Location: All activities will take place on Mining Licence (ML) 134, held by Afritin Mining Namibia (Pty) Ltd, Erongo Region.

Proposed Activities: Uis Tin Mining Company (Pty) Ltd proposes several mechanical and process flow upgrades to components of the current pilot plant's processing and supporting infrastructure and therefore an expected increase in the production rate from the current 60 Tons Per Hour (TPH) in stage 1 to 120 TPH in stage 2. This equates to a life of Operations of 20 years.

Purpose of the review and registration period: The purpose of the review and registration period is to introduce the proposed project and to afford registered Interested and Affected Parties (I&APS) an opportunity to comment on the Background Information Document (BID) to ensure that all issues, and concerns are brought forward, captured and considered further in the assessment.

The registration period is effective from the 8th of September 2021 to 22nd of September 2021. I&APs and stakeholders are required to register for the project at: www.eccenvironmental.com/projects/ or email ECC to register.

The team at ECC will then maintain contact with all registered I&APs to keep them informed and engaged as the ESIA process develops. ECC will also provide registered I&APs with all relevant documents (Impact Assessment Report and EMP) to review during the assessment process.

Environmental Compliance Consultancy
Registration Number: CC/2013/11404
Members: Mr JS Bezuidenhout
or Mrs J Mooney
PO Box 91193, Klein Windhoek
Tel: +264 81 6697 608
E-mail: info@eccenvironmental.com

website: http://www.eccenvironmental.com
Project ID: ECC-[illegible]-ADT-05-D

ECC

NILALEG

The Ministry of Environment, Forestry and Tourism (MEFT), in partnership with the United Nations Development Programme (UNDP) and Environmental Investment Fund of Namibia (EIF), wishes to invite proposals through the Namibia Integrated Landscape Approach for Enhancing Livelihoods and Environmental Governance to Eradicate Poverty (NILALEG) Project Small Grants Facility.

Grant proposals should be addressed to:
Environmental Investment Fund of Namibia
NILALEG Project Grant Facility
Heinitzburg Heights
c/o Heinitzburg and Dr. Theo-Ben Gurirab Streets
Klein Windhoek, Windhoek

Proposals should be submitted to the EIF not later than 12 November 2021 at 17h00.
Both hardcopies and emails will be accepted.
For further queries, kindly contact:

bipa

AL-ANON Family groups offer help for friends and relatives of alcoholics.

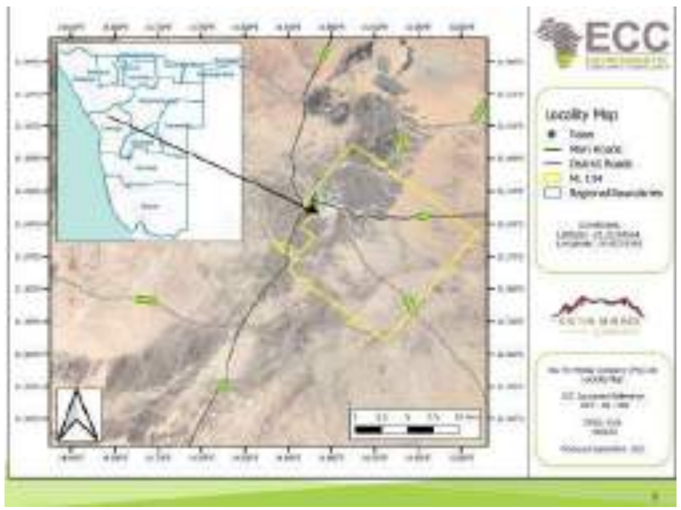
They provide assistance for people who live with alcoholics.

Dawnnam@gmail.com

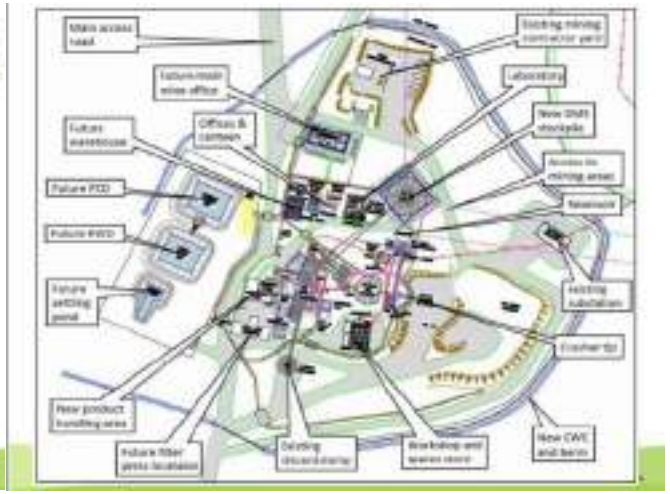
VENUE: cnr Lüderitz and Kasino Street
DATE AND TIME: Thursdays at 19H00

AL-ANON Help for relatives of Alcoholics

APPENDIX D – FOCUS GROUP MEETING PRESENTATION

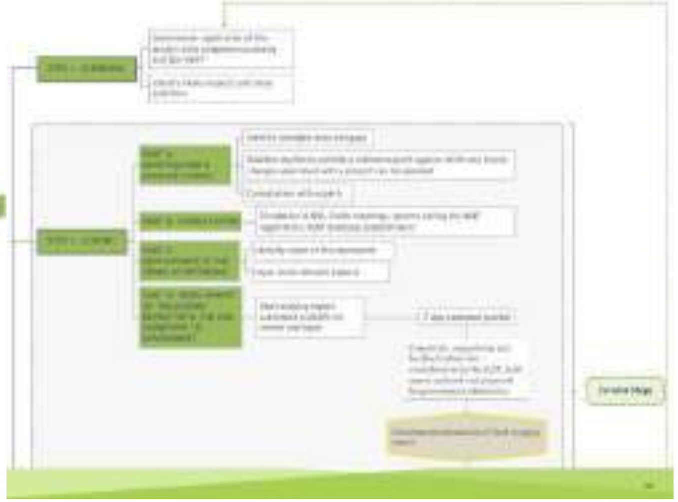



ESIA Process
ECC
Screening – DEA PORTAL
ACTIVITIES THAT TRIGGERED A CLEARANCE CERTIFICATE APPLICATION
ENERGY GENERATION, TRANSMISSION AND STORAGE ACTIVITIES
WASTE MANAGEMENT, TREATMENT, HANDLING AND DISPOSAL ACTIVITIES
MINING AND QUARRYING ACTIVITIES
WATER RESOURCE DEVELOPMENT
HAZARDOUS SUBSTANCE TREATMENT, HANDLING AND STORAGE

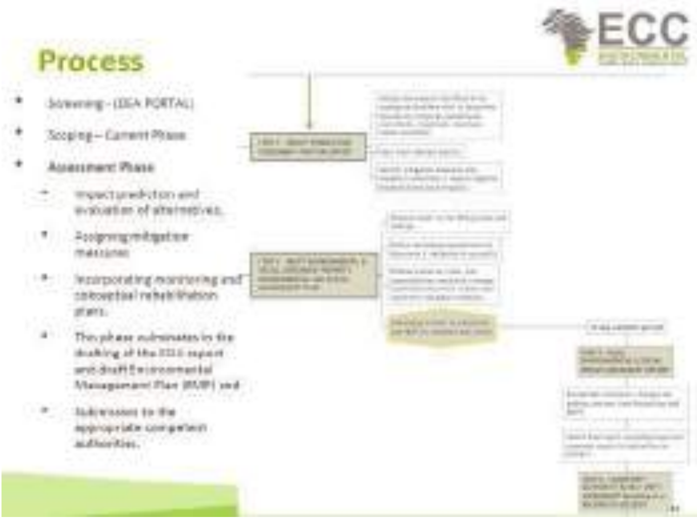

Main access road
Existing mining contractor yard
Future main mine office
Laboratory
Offices & canteen
Future warehouse
New DMS stockpile
Access to mining areas
Future PCD
Future RWD
Reservoir
Future settling pond
Existing substation
Crusher(s)
New product handling area
Future filter press location
Existing discard dump
Workshop and spares store
New CWC and berm


About Uis Tin Mining Company (Pty)Ltd...
Namibian registered subsidiary of Afritin Mining.
Commenced infrastructure development in 2018 on the historical Uis Tine Mine footprint.
The project is operating in two phases; phase 1 the current pilot plant that employs approximately 93 - 150 personnel, and phase 2 (future development) will be full scale mining which will employ 450 - 550 personnel.
Uis Tin Mining Company (Pty) Ltd proposes several mechanical and process flow upgrades to components of the current pilot MHCP plant's processing and supporting infrastructure.
Dewatering of the grits tailings (less than 630 microns).
Dewatering of the slimes tailings (less than 45 microns) and
Expanding the feed capacity to the spiral plant.
The modifications are expected to more than double the throughput capacity of these circuits and therefore an expected increase in the production rate from the current 50 Tons Per Hour (TPH) in stage 1 to 120 TPH in stage 2. This equates to a life of Operations of 20 years.


ESIA Process
Screening – Register the ESIA on the DEA Portal
Scoping – Current Phase
Baseline Studies
Public Participation
Terms of Reference
Assessment Phase
ECC




Public Participation
ECC
Notification of the project – newspapers & site notice boards
8/09/2023 and 15/09/2021
The Background Information Document (BID) provided I&APs with the opportunity to take part in the public participation process.
This presentation extracts information from the BID to describe the project to those attending the meeting.


Process
Screening - (EIA PORTAL)
Scoping – Current Phase
Assessment Phase


Baseline Studies
Commissioned to date
TO BE COMPLETED
ACTIVE MONITORING


Potential Impacts to be assessed
Potential impacts that can arise from the proposed project include but are not limited to:
Dust Pollution
Noise impacts
Visual impacts
Water resource impacts
Impact on archaeological and cultural features
Biodiversity impacts
Increased traffic volumes on public roads
Employment opportunities (permanent / temporary)
Growth of both local and regional economy
Others...


What you can do!
Provide in writing, any issues and suggestions regarding the proposed development. This correspondence must include:
1. Name & Surname;
2. Organization represented;
3. Position in the organization;
4. Contact details and;
5. Any direct business, financial, personal or other interest which you may have in the approval or refusal of the application.
Send written submissions to info@eccenvironmental.com
Or uploaded onto the ECC website

APPENDIX E – FOCUS GROUP MEETING ATTENDANCE REGISTERS

info@eccenvironmental.com
www.eccenvironmental.com
+264812627872
+264816831214

ENVIRONMENTAL COMPLIANCE CONSULTANCY

Meeting Attendance Register

Date: ______________

Meeting Subject: - Focus Meeting For the Afritin UTM ESIA

Venue: Uis Settlement Office Boardroom

	NAME	ORGANIZATION	EMAIL ADDRESS	CONTACT NUMBER	SIGNATURE
1	Jason Amukwa	ERC - Uis	jamukwa@erc.gov.na	0813735391	[signature]
2	Efraim Tourob	UTMC	efraimtourob@afritinmining.com	0818027822	[signature]
3					
4					
5					
6					
7					
8					
9					
10					
11					

info@eccenvironmental.com
www.eccenvironmental.com
+264812627872
+264816531214

ENVIRONMENTAL COMPLIANCE CONSULTANCY

Meeting Attendance Register

Date: 19/10/2021

Meeting Subject: Public Meeting for the Afritin UTM ESIA

Venue: Uis Settlement Office Boardroom

	NAME	ORGANIZATION	EMAIL ADDRESS	CONTACT NUMBER	SIGNATURE
1	MR. I. Kamenda	FARMERS Elders	—	0817327146	[illegible]
2	Ranga Tsibeb	E/REO	rtsibeb@2gmail.com	0812293976	Rang
3	Julia Garises	Resource Management group Tsiseb/UIS		0812444417	Garises
4	RALF SCHOMMARZ	Uis Tin MINE	ralf.schommarz@afritinmining.com	081 124 7395	[illegible]
5	Amingo Homob	UIS-ERC	amingohomob@ymail.com	0812545970	[illegible]
6	JOHANNES GARISEB	Brandbergsmallminer	johannesgariseb@gmail.com	0813092097	[illegible]
7	Helen Geingos	BrandbergPS	geingoshelen@gmail.com	0812857133	[illegible]
8					
9					
10					
11					

APPENDIX F – SITE NOTICES

NOTICE OF AN ENVIRONMENTAL ASSESSMENT & PUBLIC PARTICIPATION PROCESS FOR THE PROPOSED STAGE 2 EXPANSION OF THE PILOT TIN PROCESSING PLANT ON ML 134, ERONGO REGION, NAMIBIA.

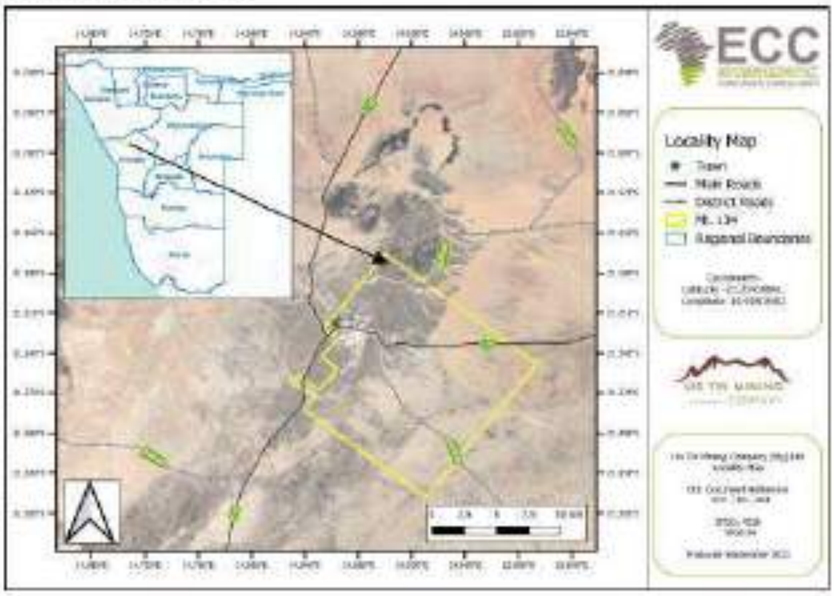
Environmental Compliance Consultancy cc (ECC) hereby gives notice to the public that an application for an environmental clearance certificate in accordance with the Environmental Management Act, No. 7 of 2007 will be made as per the following:

Applicant:	**Uis Tin Mining Company (Pty) Ltd**
Environmental Assessment Practitioner (EAP):	Environmental Compliance Consultancy
Location:	Uis, Erongo Region, Namibia
Project ID:	**ECC-84-284**

Proposed Project Activity: The proposed project involves the stage 2 expansion of the pilot tin processing plant on Mining Licence (ML) 134, held by Uis Tin Mining Company (Pty) Ltd.

Uis Tin Mining Company (Pty) Ltd proposes several mechanical and process flow upgrades to components of the current pilot plant's processing and supporting infrastructure and therefore an expected increase in the production rate from the current 80 Tons Per Hour (TPH) in stage 1 to 120 TPH in stage 2. This equates to a life of Operations of 20 years.

Proposed Project Area: Erongo Region, Namibia



I&APs Registration: The purpose of the registration period is to introduce the proposed project and to afford Interested and Affected Parties (I&APs) an opportunity to register and comment on the Background Information Document (BID), to ensure that potential issues and concerns are brought forward, so that they can be considered and assessed during the impact assessment process.

I&APs and stakeholders are required to register for the project at: www.eccenvironmental.com/projects

The team at ECC will then maintain contact with all registered I&APs to engage and to keep them informed as the ESIA process develops. ECC will also provide registered I&APs input opportunities and review periods throughout the assessment process.

ECC ENVIRONMENTAL COMPLIANCE CONSULTANCY

Contact: Mr JS Bezuidenhout or Mrs J Mooney
Environmental Compliance Consultancy
Registration Number: CC/2013/11404
PO Box 91193, Klein Windhoek
Tel: +264 81 669 7608
email: info@eccenvironmental.com
Website: www.eccenvironmental.com/projects

CURRICULUM VITAE

JESSICA BEZUIDENHOUT

Name of Consultant:	Jessica Bezuidenhout
Position / Profession:	Environmental Specialist
Date of Birth:	24 October 1984
Nationality:	Australian – Namibian Domicile, mother of a Namibian child.
Email:	jessica@eccenvironmental.com
Website:	www.eccenvironmental.com
Contact:	+264 81 653 1214

TERTIARY EDUCATION:

Federation University Australia: **2003 – 2006** Bachelor of Applied Science – Environmental Management

OTHER TRAINING:

- Management Systems Leadership
- ICAM – Incident Causes Analysis Method
- Certificate II in Metalliferous Mining Core Safety and Risk Management
- Certificate III in Mine Emergency Response & Rescue
- Level 3 – HLTFA402B Apply Advance First Aid Emergency Rope Rescue
- Level 2 – 21593VIC First Aid Level 2 Bonded Asbestos Removal > $10m^2$
- Leading and Managing People – Brisbane North Institute of TAFE

Professional Associations:

- Chamber of Mines Namibia
- Women on Boards
- The Chamber of Minerals and Energy of Western Australia Industry Member – Mining, Minerals and Resources
- Environmental Assessment Professional Association of Namibia (EAPAN)

PROFILE:

Jessica works as a Lead Environmental Practitioner with a diverse environmental background. Mrs Bezuidenhout has leading practical experience in fields of construction, exploration, monitoring and audit compliance, consultancy, operations, water treatment and wastewater treatment plants, environmental approvals, legal, minimising operational impacts, community liaison, including indigenous relationship management, mine closure and rehabilitation.

KEY AREAS OF EXPERTISE:

Environmental Management	-	Project Management
Environmental (and social) Impact Assessments (EIAs)	-	Conducting and managing various small to large scale EIAs Compiling EIA Reports and EMPs Coordinate and review specialist studies
Environmental & Social Compliance reporting	-	Environmental and Social compliance audits in the construction and mining industry

LANGUAGES:

	Read	Write	Speak
English	Excellent	Excellent	Excellent

SUMMARY OF EXPERIENCE AND CAPABILITY:

Jessica has 15 years of mining and construction experience in the SHEQ field, with 7 years of that being in Australia and 8 years in Namibia and Southern Africa. Her first three years were as an Environmental Systems Coordinator where she obtained regulatory approvals, oversaw operational budgets and bond management for mine closures, oversaw compliance and ensured environmental and social aspects of international management codes were adhered to. The following 3 years she worked in the environmental management field as a Site Environmental Manager managing various projects and brining sites into full compliance with environmental legislative frameworks, while also being responsible for the environment, sustainability, and social reporting portfolio. She then went on to work as an Environmental Consultant where she was responsible for mine closure and rehabilitation and sustainability reporting. Since 2016 Jessica has been a Managing Director of Environmental Compliance Consultancy (ECC) spearing heading many environmental impact assessments undertaken in Southern Africa, advising clients and has thus gained great practical experience and knowledge on local and international compliance and auditing standards such as IFC and the World Bank.

PROJECT EXPERIENCE

PROJECT	DATE	ROLE
Contracted services by The Australian Defence Force (ADF) for Environmental Management of Defence projects.	2006 – 2007	Environmental Project Manager
Site environmental officer and systems coordinator, Ballarat Goldfields.	2007 – 2010	Environmental Systems Coordinator
Managed the environmental and community aspects of three operations: Savannah Nickel Mine, Copernicus Nickel Mine (currently in care and maintenance) and the operations at Wyndham Port	2010-2013	Site Environmental Manager
A mine closure project taking an operating mine site into the rehabilitation and closure phase. This project involved the full development of a mine closure plan, facilitation of the government	2013-2014	Environmental Consultant

approvals, stakeholder engagement and technical environmental studies to inform the mine closure plan		
Full scale construction of new greenfield mine into an operational copper mine - Tschudi	2013-2016	HSE Manager
HSE management of operational underground mines, Otjihase and Matchless	2013-2016	HSE Manager
Director Environmental Compliance Consultancy	2016 – Current	Director and principle environmental practitioner
Projects completed while at ECC		
The Environmental Impact Assessment (EIA) for the proposed Walvis Bay Waterfront development	2018	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Conduct the Namibian assessment on the laws and policies relating to six thematic areas based on a compendium of best practices for governments to best deal with the full range of issues related to mining.	2018	Lead Environmental Assessment Practitioner
ESIA amendment for B2Gold Namibia Mining Licence (ML 169) to developed underground mine working for the Otjikoto Gold Mine	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Kunene Regional Counsel Sustainable water supply Pipeline and Ancillary works	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
ESIA application for B2Gold Namibia 10.8 megawatt PV solar upgrade to the B2Gold Power Plant	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
EIA application for sand removal on Farm Okakongo Nord No. 58	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
EIA application for Uris irrigation scheme	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
MAWF permit application for Water Abstraction and Discharge for Uris Irrigation scheme	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
EIA application for University of Namibia (UNAM) Katima Mulilo Campus Expansion	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
EIA application for B2Gold exploration activities EPL 6627 & EPL 6628	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and

		PPP and report review)
ESIA application for farm Tsumore 761 Unit B Irrigation Project	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
MAWF permit application for Water Abstraction and Discharge for Tsumore 761 Unit B Irrigation Project	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
ESIA application for Otjiwarongo Wastewater Treatment and Bulk Water Supply	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
ESIA for the Wastewater Treatment facilities for Gondwanan Collection	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
MAWF permit application for Water Abstraction and Discharge for Gondwanan Collection	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Conduct an environmental assessment in order to complete an Environmental Impact Assessment and Environmental Management Plan (EMP) for Marenica Energy.	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Appointed Environmental Practitioner for the B2Gold exploration activities on EPL 6949. Conduct an environmental assessment in order to complete an Environmental Impact Assessment and Environmental Management Plan (EMP)	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Engaged by Marenica Energy to undertake an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP) for EPL's 6663, 7435, 7436, 7278 & 7279 for Nuclear Fuel Minerals	2019	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Engaged by Marenica Energy to undertake an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP) on EPL's : 7703, 7340, 7303 & 7172 for Base and Rare Metals, Industrial Minerals, Precious Metals and Semi-Precious Stones.	2020	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Engaged by Mertens Mining and Trading (Pty) Ltd, to undertake an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP) to undertake bulk sampling, exploration activities and trial processing on EPL 7699.	2020	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Engaged by Kuiseb Copper Company (Pty) (Ltd) to undertake an ESIA and an Environmental	2020	Lead Environmental Assessment Practitioner managing the EIA process

Management Plan (EMP) for EPLs: 7528, 7529, 7530, 7531, 7532, 7533, 7534, 7535, 7536, 7537, 7538, 7539, 7540, 7541, 7542, 7543, 7730, 7731, 7732,		(including stakeholder engagement and PPP and report review)
Exploration by Cheetah Minerals	2020	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Engaged by Skorpion Zinc (Namzinc) (Pty) (Ltd) to undertake an ESIA and an Environmental Management Plan (EMP)	2021	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Engaged by Afritin Mining Namibia (Pty) Ltd to undertake the ESIA and Environmental Management Plan (EMP)	2021	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Project Wings - engaged by Headspring Investments (Pty) Ltd to undertake the Environmental, Social and Impact Assessment and Environmental Management Plan	2021	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Application for an Environmental Clearance Certificate for Twin Hills Gold Project	2021	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Engaged by Votorantim Metals Namibia (Pty) Ltd to undertake the ESIA and Environmental Management Plan (EMP) for exploration activities on EPL 8127	2021	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)
Engaged by to undertake an ESIA and an Environmental Management Plan (EMP) for the stage 2 expansion of the pilot tin processing plant on Mining Licence (ML) 134, held by Uis Tin Mining Company	2021	Lead Environmental Assessment Practitioner managing the EIA process (including stakeholder engagement and PPP and report review)

CERTIFICATION:
I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and experience.

DATE: 10/ 11 / 20

FULL NAME OF CONSULTANT: JESSICA BEZUIDENHOUT

Blast Management & Consulting

Quality Service on Time

Report: Blast Impact Assessment at New bulk sampling, sorting, and testing facility Stage II expansion at Afritin Mine, Uis on ML 134 Project

Report Date:	07 September 2022	
BM&C Ref No:	BMC_ECC_Afritin Mine Uis_EIAReportAddendum_220907	
Client Ref No:	ECC 84-284	
Document Authorised:	JD Zeeman	

i. Document Prepared and Authorised by:

JD Zeeman
Blast Management & Consulting (2015/061002/07)
61 Sovereign Drive
Route 21 Corporate Park
Irene
South Africa

PO Box 61538
Pierre van Ryneveld
Centurion
0045

Cell: +27 82 854 2725 Tel: +27 (0)12 345 1445 Fax: +27 (0)12 345 1443

ii. Document Control:

Name & Company	Responsibility	Action	Date	Signature
JD Zeeman Blast Management & Consulting	Consultant	Addendum to EIA Report	07/09/2022	

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List of Figures

1 Introduction

Additional infrastructure at AfriTin Mining Limited (“AfriTin”) was evaluated for possible impact. The additional infrastructure consists of a bulk sampling, sorting, and testing facility. The planned new infrastructure was placed on plan and reviewed if blasting could have influence.
The location of new infrastructure is illustrated in Figure 1.

Figure 1: Location of new infrastructure

Figure 2 shows zoomed area of the infrastructure.

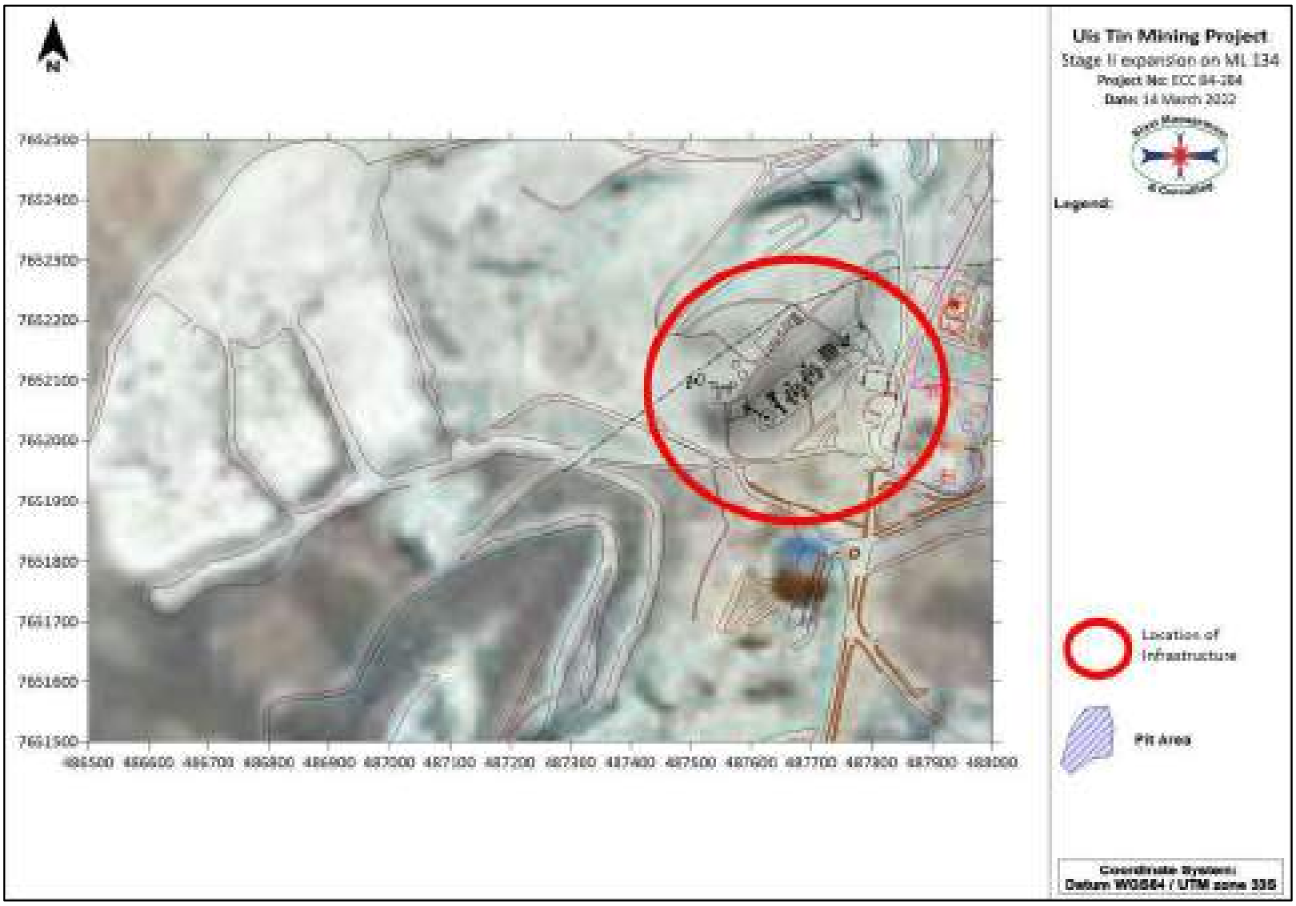

Figure 2: Zoomed area of infrastructure

2 Impact Evaluation

2.1 Ground Vibration:

Review of the location of the new infrastructure from the pit area it is expected that ground vibration levels from maximum charge is in the order of 12.5 mm/s.

These levels are well within accepted norms for this type of infrastructure. No negative influence is expected from ground vibration due to blasting operations. It must be noted that blasting operations further away from the new infrastructure will yield lower levels at this plant.

The following figure shows the modelled ground vibration levels in relation to the new plant.

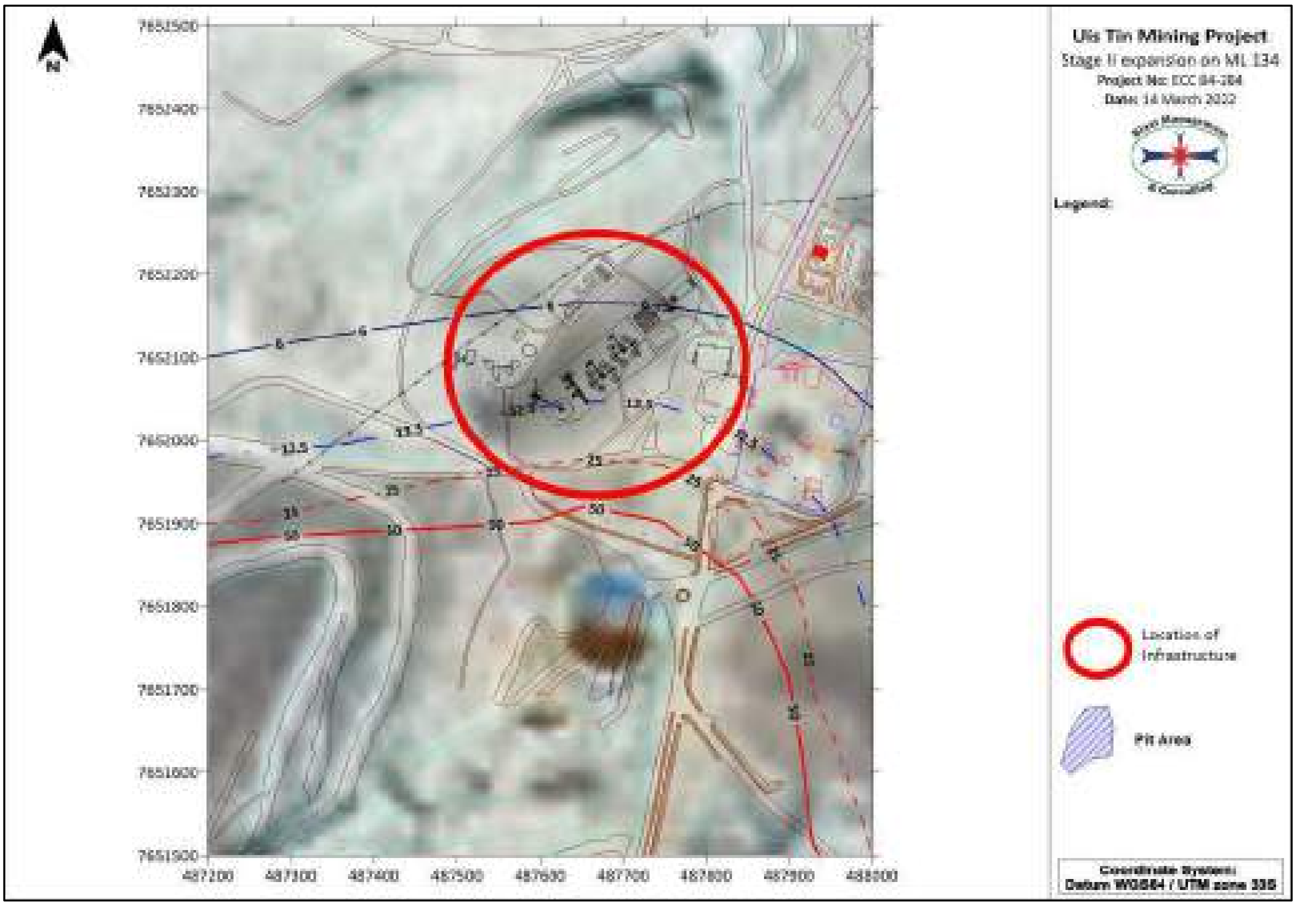

Figure 3: Ground Vibration levels

2.2 Air blast:

Air blast was not considered. Air blast is not expected to have any influence on this type of plant.

2.3 Fly Rock:

The expected fly rock range is 388 m. The new infrastructure is located within this range at 214 m. The plant will be within range of possible fly rock when blasting is done in this northern section of the mine. Adjustments can be made to the stemming lengths and blast hole diameters to ensure better control on fly rock. The following figure shows the location of the plant in relation with the pit area and fly rock range indicated.

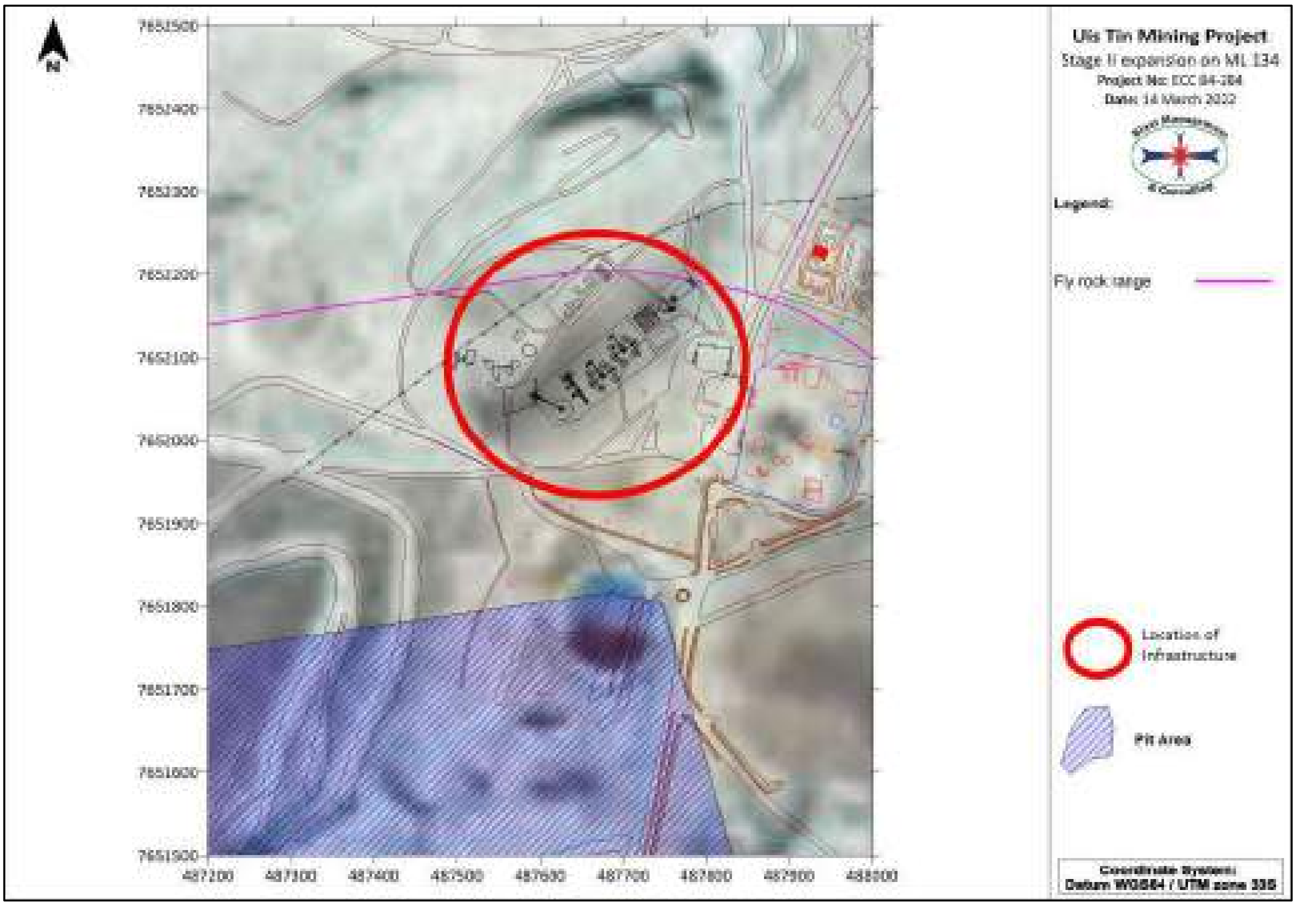

Figure 4: Fly rock range

3 Conclusion

The planned new plant (bulk sampling, sorting, and testing facility) was evaluated for possible influence from blasting operations with regards to ground vibration, air blast and fly rock. Ground vibration expected at the plant is well within limits with no specific negative influence expected. Air blast does not have any significant influence of these type of structures. The location of the plant is within range from possible fly rock. Blasting in the northern section of the mine will require some mitigation or changes to blast designs to ensure damage is not induced to the plant.

4 References

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2. Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.
3. Dowding C.H., Construction Vibrations, 1996, Prentice Hall, Upper Saddle River, NJ 07458.
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5. Mechanical vibration and shock – Vibration of buildings – Guidelines for the measurement and evaluation of their effects on buildings, SABS ISO 4886:1990.
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8. Richards A. B., Moore A.J., Terrock Consulting Engineers Pty Ltd., 2002, Fly rock Control – By Chance or Design, Paper Presented at ISEE Conference – New Orleans.
9. Rowland, J.H.(III), Mainiero R., and Hurd D.A.(Jr.), Factors Affecting Fumes Production of an Emulsion and Anfo/Emulsion Blends.
10. Sapko M., Rowland J., Mainiero R., Zlochower I., Chemical and Physical Factors that Influence no Production during Blasting – Exploratory Study.
11. Scott A., Open Pit Blast Design, 1996, Julius Kruttschnitt Mineral Research Centre, The University of Queensland.
12. Siskind D.E., Stachura V.J., Stagg M.S. and Kopp J.W., 1980. Structure Response and Damage Produced by Air Blast from Surface Mining. US Bureau of Mines RI 8485.

Blast Management & Consulting

Quality Service on Time

Report: Blast Impact Assessment Stage II expansion at Afritin Mine, Uis on ML 134 Project		
Report Date:	23 February 2022	
BM&C Ref No:	BMC_ECC_Afritin Mine Uis_EIAReport_220223	
Client Ref No:	ECC 84-284	
Document Authorised:	JD Zeeman	

i. Document Prepared and Authorised by:

JD Zeeman
Blast Management & Consulting (2015/061002/07)
61 Sovereign Drive
Route 21 Corporate Park
Irene
South Africa

PO Box 61538
Pierre van Ryneveld
Centurion
0045

Cell: +27 82 854 2725 Tel: +27 (0)12 345 1445 Fax: +27 (0)12 345 1443

ii. Study Team Qualifications and Background

The study team comprises J D Zeeman (as the member of Blast Management & Consulting) and Blast Management & Consulting employees. Blast Management & Consulting's main areas of concern are pre-blast consultation and monitoring, insitu monitoring, post-blast monitoring and consulting as well as specialised projects. Blast Management & Consulting has been active in the mining industry since 1997 and work has been done at various levels for mining companies in South Africa, Botswana, Namibia, Mozambique, Democratic Republic of Congo, Sierra Leone and Côte d'Ivoire.

J D Zeeman holds the following qualifications:

1985 - 1987	Diploma: Explosives Technology, Technikon Pretoria
1990 - 1992	BA Degree, University of Pretoria
1994	National Higher Diploma: Explosives Technology, Technikon Pretoria
1997	Project Management Certificate, Damelin College
2000	Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosive Engineers

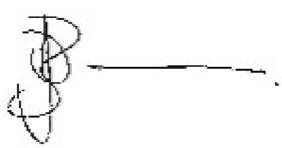
iii. Independence Declaration

i. Independence Declaration

A declaration that the specialist is independent in a form as may be specified by the competent authority

I, JD Zeeman, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct



Signature of the Specialist

ii. Document Control:

Name & Company	Responsibility	Action	Date	Signature
C Zeeman Blast Management & Consulting	Document Preparation	Report Prepared	23/02/2022	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalised	30/03/2022	

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List of Acronyms used in this Report

a and b	Site Constant
APP	Air Pressure Pulse
B	Burden (m)
BH	Blast Hole
BMC	Blast Management & Consulting
D	Distance (m)
E	Explosive Mass (kg)
EIA	Environmental Impact Assessment
Freq.	Frequency
GRP	Gas Release Pulse
I&AP	Interested and Affected Parties
k	Factor value
L	Maximum Throw (m)
Lat/Lon hddd°mm'ss.s"	Latitude/Longitude Hours/degrees/minutes/seconds
M	Charge Height
m (SH)	Stemming height
M/S	Magnitude/Severity
Mc	Charge mass per metre column
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
NOx's	Noxious Fumes
P	Probability
POI	Points of Interest
PPV	Peak Particle Velocity
RPP	Rock Pressure Pulse
SH	Stemming height (m)
USBM	United States Bureau of Mine
W	West
WM	With Mitigation Measures
WOM	Without Mitigation Measures

List of Units used in this Report

%	percentage
cm	centimetre
dB	decibel
dBL	linear decibel
g/cm^3	gram per cubic centimetre
Hz	frequency
kg	kilogram

kg/m^3	kilogram per cubic metre
kg/t	kilogram per tonne
km	kilometre
kPa	kilopascal
m	metre
m^2	metre squared
MJ	Mega Joules
MJ/m^3	Mega Joules per cubic meter
MJ/t	Mega Joules per tonne
mm/s	millimetres per second
mm/s^2	millimetres per second square
ms	milliseconds
Pa	Pascal
ppm	parts per million

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1 Executive Summary

Blast Management & Consulting (BMC) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed opencast mining operation.

Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report evaluates the effects of ground vibration, air blast and fly rock and intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed is typical roads (tar and gravel), low cost houses, corrugated iron structures, brick and mortar houses, communication towers.

The location of structures around the Pit area is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Power Lines, Boreholes and Mine Buildings/Structures. Ground vibrations predicted for the pit area ranged between low and very high. The expected levels of ground vibration for some of these structures are high and will require specific mitigations in the way of adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Air blast predicted also showed more concerns for opencast blasting. The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134dB. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located such that “free blasting” – meaning no controls on blast preparation – will not be possible. The nearest private structures are located 1324 m from pit edge. Air blast levels from maximum charge is expected to be within the accepted limit but slightly greater than 120 dB. This may contribute to some complaints. All other private structures are further away and levels decrease over distance. Levels are expected to be less than 120 dB at distance of 2387 m from the pit edge.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 223 m and closer to pit boundary. Infrastructure at the pit areas such as roads, power lines/pylons are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 388 m. The absolute minimum unsafe zone is then the 388 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Power Lines, Stormwater Canal and Mine Buildings/Structures falls within the 500 m range from the pit area.

The pit areas are located such that specific concerns were identified and addressed in the report.

This concludes this investigation for the proposed Uis Tin Mining Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

2 Introduction

AfriTin Mining Limited ("AfriTin") executed a Definitive Feasibility Study ("DFS") between October 2020 and December 2020 for the expansion of production at Uis Tin Mine in Namibia. This expansion is intended to fast-track opportunities and to exploit the financial benefit inherent in these opportunities.

The proposed expansion is in line with the Company's strategy for expansion of the Uis Phase 1 project, and forms part of the Phase 1 Stage II expansion, however it does not cover the full scope of the defined Stage II goals.

The aim is to fast-track some of the Stage II expansion objectives by leveraging certain capabilities. The expanded materials handling and concentrating plant ("MHCP") is designed to increase the average monthly production of 60 t of tin concentrate to 100 t. This will be achieved by increasing the feed rate of ore to the concentrating plant by 50% and improving the operation of the concentrating circuit to achieve consistent recovery of 64% of contained tin.

The Uis Tin Mine infrastructure development commenced in 2018 on the historical Uis Tin Mine located adjacent to the Uis mining village which was developed to support the historical mine.

Access to the project is obtained via an established road network that connects the project to larger towns and cities with modern infrastructure. The two main access routes to the project are via the C36 from the town of Omaruru and the C35 from the town of Henties Bay. Both these roads are two-way gravel roads that are maintained by the local road authorities. The condition of the roads is very good and allow for easy and efficient traveling and transport.

From the towns of Henties Bay and Omaruru access can be gained to larger towns and cities via tarred roads. The closest large town to the project is Swakopmund and is located 165 km by road from the project. Walvis Bay is a port city 40 km from Swakopmund by road, with an international airport, and import and export infrastructure. Swakopmund is also connected to the town of Omaruru via rail.

Uis is located approximately 270 km northwest of the Namibian capital Windhoek. Imports of industrial goods and equipment from South Africa are via Windhoek, while most imports from overseas come by sea through Walvis Bay. Concentrate export is also by sea via Walvis Bay.

The location of the project in relation to other towns and cities and access routes are illustrated in Figure 1.

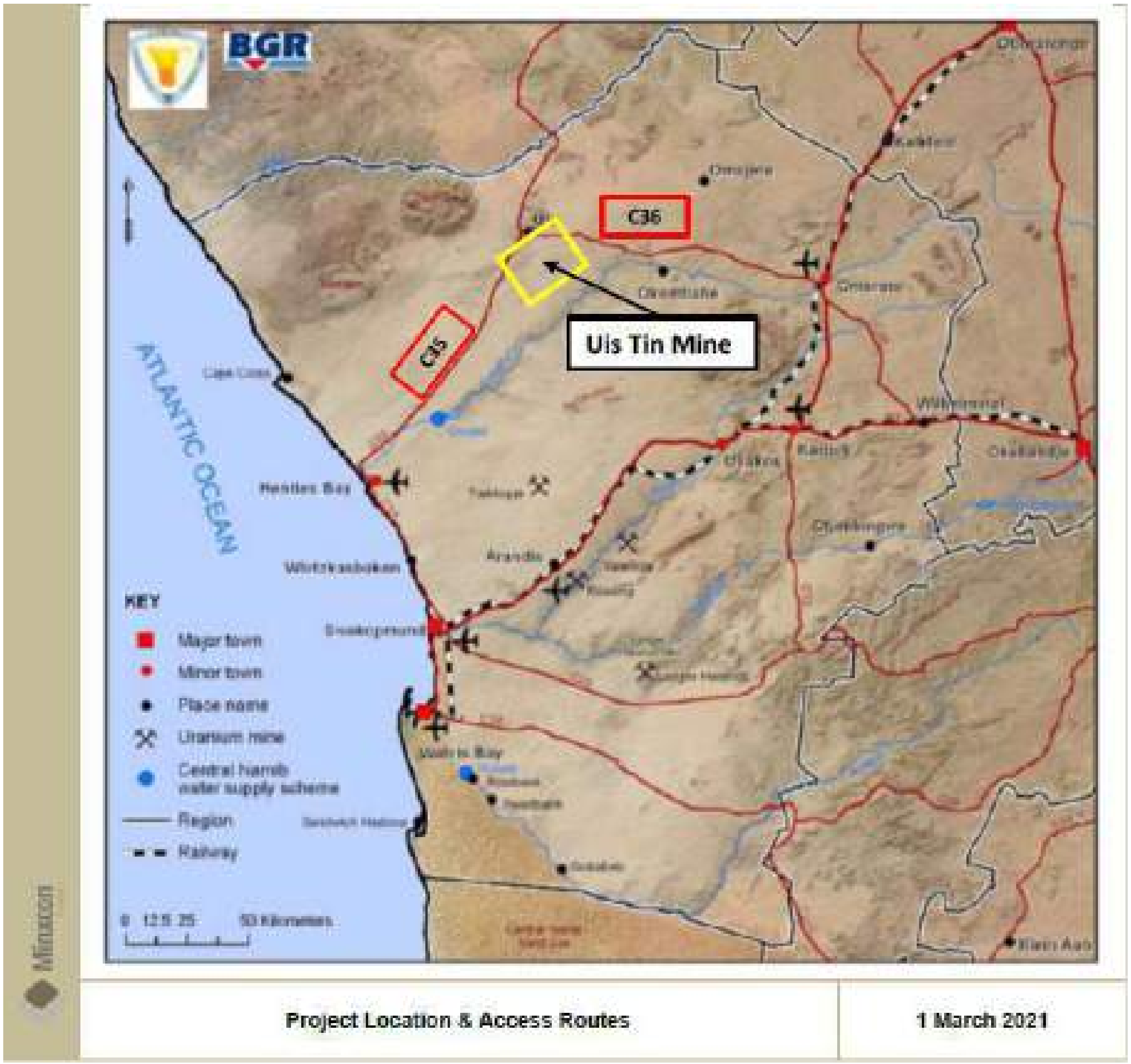

Figure 1: Project Location and Access Routes

Figure 2 indicates the relative position of the proposed open cast mining area (blue polygon).

Figure 2: Location of the proposed opencast mining area

3 Objectives

The objectives of this document are outlining the expected environmental effects that blasting operations could have on the surrounding environment; and proposing the specific mitigation measures that will be required. This study investigates the related influences of expected ground vibration, air blast and fly rock. These effects are investigated in relation to the blast site area and surrounds and the possible influence on nearby private installations, houses and the owners or occupants.

The objectives were dealt with whilst taking specific protocols into consideration. The protocols applied in this document are based on the author's experience, guidelines taken from literature research, client requirements and general indicators in the various appropriate Namibian legislation. There is no direct reference in the following acts to requirements and limits on the effect of ground vibration and air blast and some of the aspects addressed in this report:

- Petroleum Products Regulations : Petroleum Products And Energy Act 13 of 1990
- Minerals (Prospecting And Mining) Act 33 of 1992
- Mine Health & Safety Regulations, 10th Draft
- Diamond Act 13 of 1999
- Mineral Act, 1992
- Annotated Statutes Explosives Act 26 of 1956.

The guidelines and safe blasting criteria are based on internationally accepted standards and specifically criteria for safe blasting for ground vibration and recommendations on air blast published by the United States Bureau of Mines (USBM).

4 Scope of blast impact study

The scope of the study is determined by the terms of reference to achieve the objectives. The terms of reference can be summarised according to the following steps taken as part of the EIA study with regards to ground vibration, air blast and fly rock due to blasting operations.

- Background information of the proposed site.
- Blasting Operation Requirements.
- Site specific evaluation of blasting operations according to the following:
    - Evaluation of expected ground vibration levels from blasting operations at specific distances and on structures in surrounding areas;
    - Evaluation of expected ground vibration influence on neighbouring communities;
    - Evaluation of expected blasting influence on national and provincial roads surrounding the blasting operations if present;
    - Evaluation of expected ground vibration levels on water boreholes if present within 1500 m from blasting operations;
    - Evaluation of expected air blast levels at specific distances from the operations and possible influence on structures;
    - Evaluation of fly rock unsafe zone;
    - Discussion on the occurrence of noxious fumes and dangers of fumes;
    - Evaluation the location of blasting operations in relation to surrounding areas according to the regulations from the applicable Acts.
- Impact Assessment.
- Mitigations.
- Recommendations.
- Conclusion.

5 Study area

Uis Tin Mine is located to the south-east of the town of Uis, located in the Erongo Region of Namibia. Old infrastructure, open pits, and discarded waste dumps from previous mining in the area are still visible. The new mine is located to the south of the old plant area. The centre point of the Pit is 21°14'42.46"S and 14°52'34.90"E. Figure 3 shows the location map of the proposed opencast mining area (Blue Polygon).

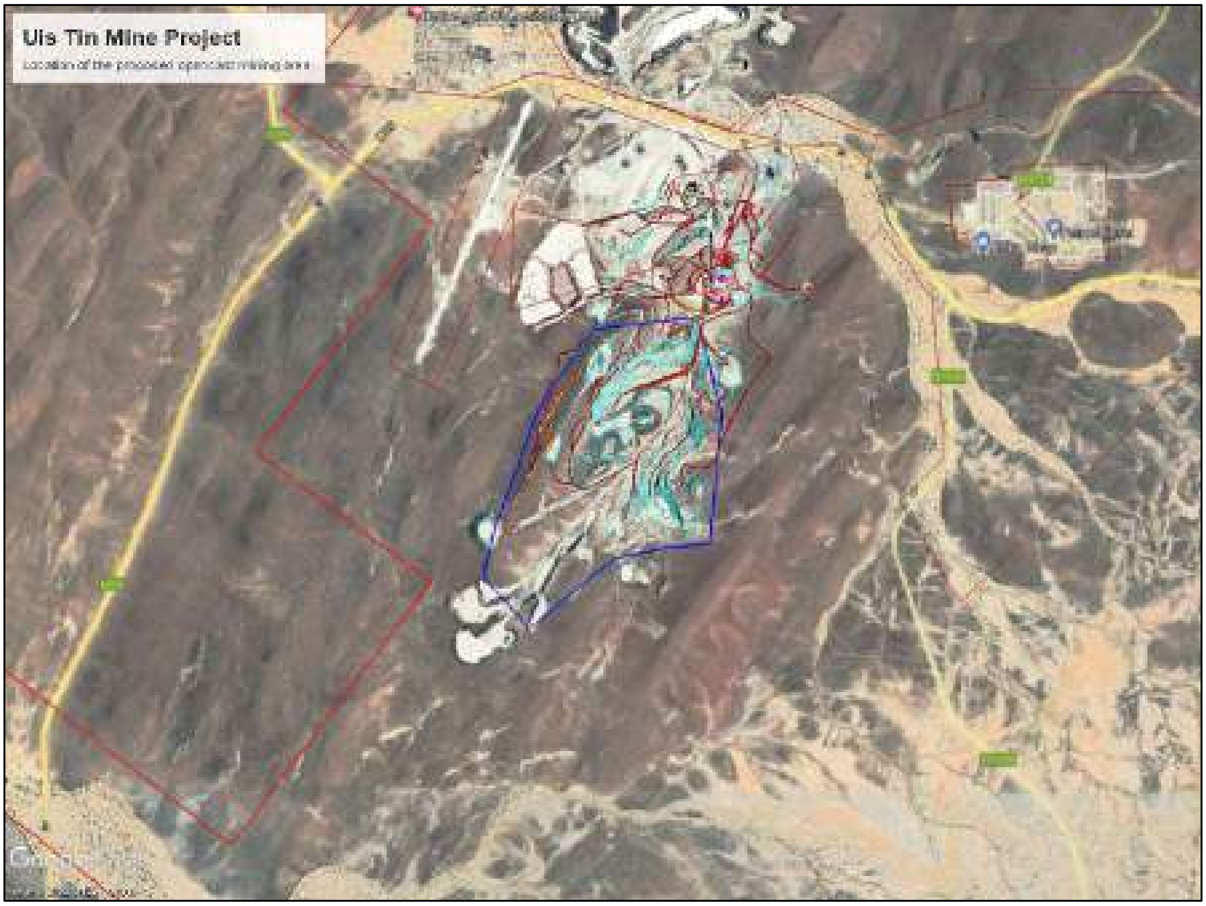

Figure 3: Location of the proposed opencast mining area

6 Methodology

The detailed plan of study consists of the following sections:

- Identifying surface structures / installations that are found within reason from project site. A list of Point of Interests (POI's) is created that will be used for evaluation. Google Earth imagery was used.
- Site evaluation: This consists of evaluation of the mining operations and the possible influences from blasting operations. The methodology is modelling the expected impact based on the expected drilling and blasting information provided for the project. Various accepted mathematical equations are applied to determine the attenuation of ground vibration, air blast and fly rock. These values are then calculated over the distance investigated from site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors then gives an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels then gives an indication of the possible mitigation measures to be applied. The possible environmental or social impacts are then addressed in the detailed EIA phase investigation.

- Reporting: All data is prepared in a single report and provided for review.

7 Season applicable to the investigation

The drilling and blasting operations are not season dependable. The investigation into the possible effects from blasting operations is not season bounded.

8 Assumptions and Limitations

The following assumptions have been made:

- The anticipated levels of influence estimated in this report are calculated using standard accepted methodology according to international and local regulations.
- The assumption is made that the predictions are a good estimate with significant safety factors to ensure that expected levels are based on worst case scenarios. These will have to be confirmed with actual measurements once the operation is active.
- The limitation is that limited data was available from this operation. No confirmation of the predicted values could be made.
- Blast designs applied currently was used for the evaluation inputs.
- The work done is based on the author's knowledge and information provided by the project applicant.

9 Legal Requirements

The Namibian legislation has been considered. There is no direct reference in the consulted acts specifically with regard to limiting levels for ground vibration and air blast. Impacts of mining are addressed but no specific reference to the blast impacts in relation to ground vibration and air blast. The following Namibian acts has been reviewed:

- Petroleum Products Regulations : Petroleum Products And Energy Act 13 of 1990
- Minerals (Prospecting And Mining) Act 33 of 1992
- Mine Health & Safety Regulations, 10th Draft
- Diamond Act 13 of 1999
- Mineral Act, 1992
- Annotated Statutes Explosives Act 26 of 1956.

The protocols applied in this document are based on the author's experience, guidelines elicited by the literature research, client requirements and international standards. Where applicable South African legislation has been consulted as well.

The guidelines and safe blasting criteria applied in this study are as per internationally accepted standards, and specifically the United States Bureau of Mines (USBM) criteria for safe blasting for ground vibration and the recommendations on air blast.

10 Sensitivity of Project

A review of the project and the surrounding areas is done before any specific analysis is undertaken and sensitivity mapping is done, based on typical areas and distance from the proposed mining area. This sensitivity map uses distances normally associated where possible influences may occur and where influence is expected to be very low or none. Two different areas were identified in this regard:

- A highly sensitive area of 500 m around the mining area. Normally, this 500 m area is considered an area that should be cleared of all people and animals prior to blasting. Levels of ground vibration and air blast are also expected to be higher closer to the pit area.
- An area 500 m to 1500 m around the pit area can be considered as being a medium sensitive area. In this area, the possibility of impact is still expected, but it is lower. The expected level of influence may be low, but there may still be reason for concern, as levels could be low enough not to cause structural damage but still upset people.
- An area greater than 1500 m is considered low sensitivity area. In this area, it is relatively certain that influences will be low with low possibility of damages and limited possibility to upset people.

Figure 4 shows the sensitivity mapping with the identified points of interest (POI) in the surrounding areas for the proposed project area. The specific influences will be determined through the work done for this project in this report.

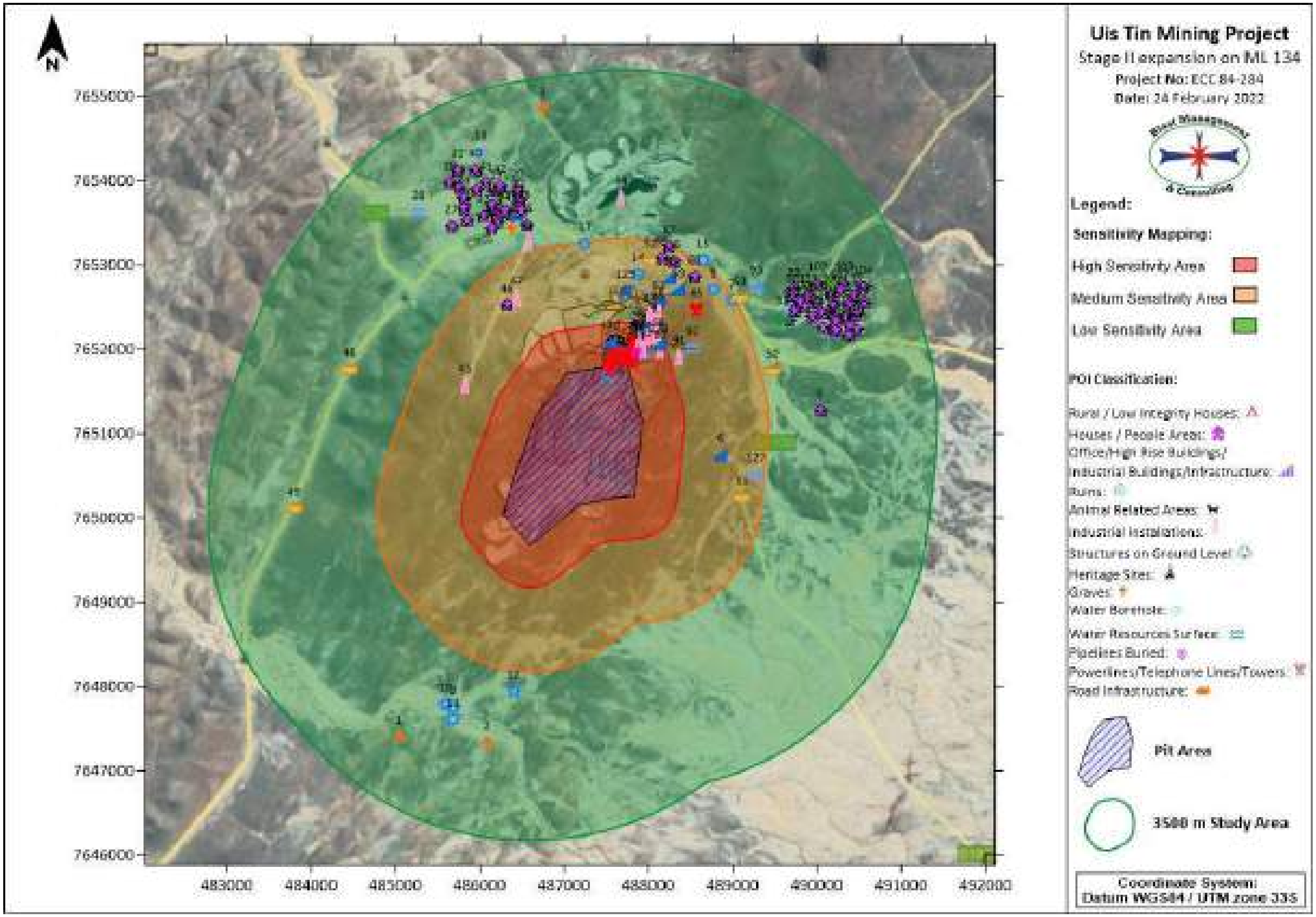

Figure 4: Identified sensitive areas

11 Consultation process

No specific consultation with external parties was utilised. The work done is based on the author's knowledge, information provided by the client and information captured during site visit.

12 Influence from blasting operations

Blasting operations are required to break rock for excavation to access the targeted ore material. Explosives in blast holes provide the required energy to conduct the work. Ground vibration, air blast and fly rock are a result of the blasting process. Based on the regulations of the different acts consulted and international accepted standards these effects are required to be within certain limits. The following sections provide guidelines on these limits. As indicated, there are no specific Namibian ground vibration and air blast limit standard.

12.1 Ground vibration limitations on structures

Ground vibration is measured in velocity with units of millimetres per second (mm/s). Ground vibration can also be reported in units of acceleration or displacement if required. Different types of structures have different tolerances to ground vibration. A steel structure or a concrete structure will have a higher resistance to vibrations than a well-built brick and mortar house. A brick and mortar house will be more resistant to vibrations than a poorly constructed or a traditionally built mud house. Different limits are then applicable to the different types of structures. Limitations on ground vibration take the form of maximum allowable levels or intensity for different installations or structures. Ground vibration limits are also dependent on the frequency of the ground vibration. Frequency is the rate at which the vibration oscillates. Faster oscillation is synonymous with higher frequency and lower oscillation is synonymous with lower frequency. Lower frequencies are less acceptable than higher frequencies because structures have a low natural frequency. Significant ground vibration at low frequencies could cause increased structure vibrations due to the natural low frequency of the structure and this may lead to crack formation or damages.

Currently, the USBM criteria for safe blasting are applied as the industry standard where private structures are of concern. Ground vibration amplitude and frequency is recorded and analysed. The data is then evaluated accordingly. The USBM graph is used for plotting of data and evaluating the data. Figure 5 below provides a graphic representation of the USBM analysis for safe ground vibration levels. The USBM graph is divided mainly into two parts. The red lines in the figure are the USBM criteria:

- Analysed data displayed in the bottom half of the graph shows safe ground vibration levels,
- Analysed data displayed in the top half of the graph shows potentially unsafe ground vibration levels:

Added to the USBM graph is a blue line and green dotted line that represents 6 mm/s and 12.5 mm/s additional criteria that are applied by BM&C.

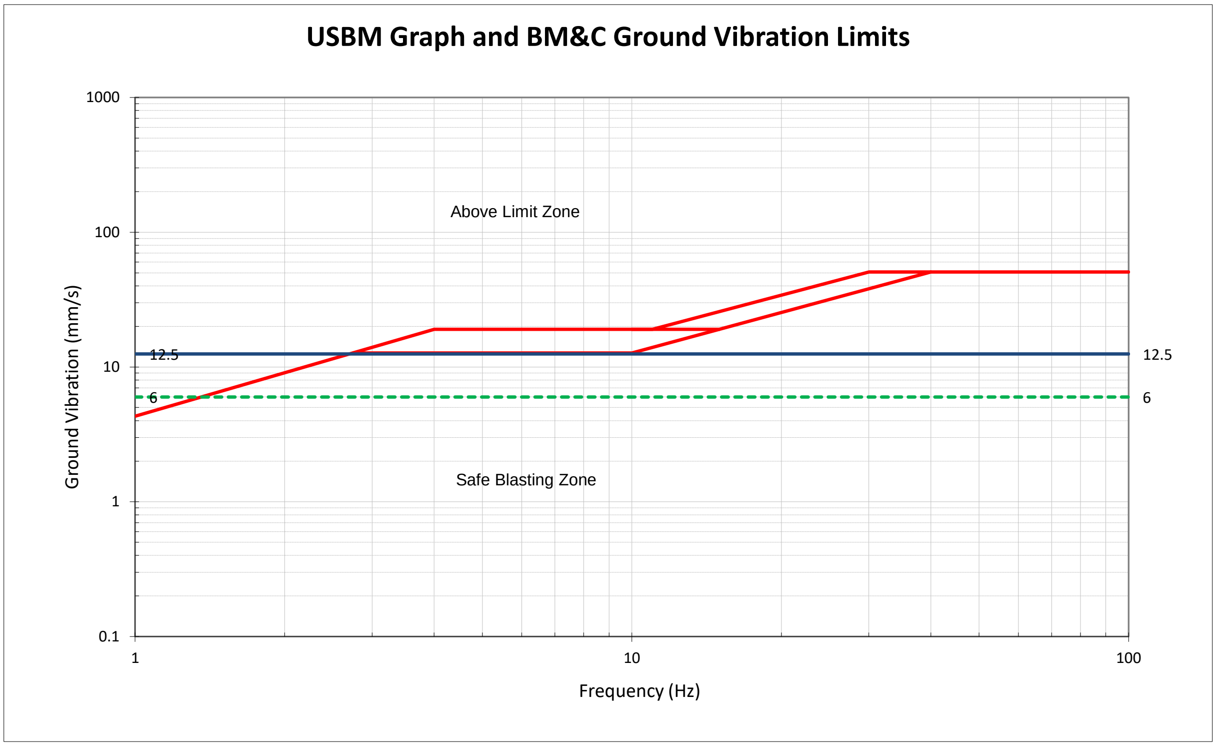

Figure 5: USBM Analysis Graph

The following additional limitations used by BMC in general and that should be considered were determined through research and prescribed by the various institutions; these are as follows:

- National roads/tar roads: 150 mm/s (BMC).
- Steel pipelines: 50 mm/s (Rand Water Board).
- Electrical lines: 75 mm/s (Eskom).
- Sasol Pipelines: 25 mms/s (Sasol).
- Railways: 150 mm/s (BMC).
- Concrete less than 3 days old: 5 mm/s [1].

[1] Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

- Concrete after 10 days: 200 mm/s [2].
- Sensitive plant equipment: 12 mm/s or 25 mm/s, depending on type. (Some switches could trip at levels of less than 25 mm/s.)[2].
- Waterwells or Boreholes: 50 mm/s [3].

Considering the above limitations, BMC work is based on the following:

- USBM criteria for safe blasting.
- The additional limits provided above.
- Consideration of private structures in the area of influence.
- Should structures be in poor condition, the basic limit of 25 mm/s is halved to 12.5 mm/s or when structures are in very poor condition limits will be restricted to 6 mm/s. It is a standard accepted method to reduce the limit allowed with poorer condition of structures.
- Traditionally built mud houses are limited to 6 mm/s. The 6 mm/s limit is used due to unknowns on how these structures will react to blasting. There is also no specific scientific data available that would indicate otherwise.
- Input from other consultants in the field locally and internationally.

12.2 Ground vibration limitations and human perceptions

A further aspect of ground vibration and frequency of vibration that must be considered is human perceptions. It should be realized that the legal limit set for structures is significantly greater than the comfort zone of human beings. Humans and animals are sensitive to ground vibration and the vibration of structures. Research has shown that humans will respond to different levels of ground vibration at different frequencies.

Ground vibration is experienced at different levels; BMC considers only the levels that are experienced as “Perceptible”, “Unpleasant” and “Intolerable”. This is indicative of the human being’s perceptions of ground vibration and clearly indicates that humans are sensitive to ground vibration and humans perceive ground vibration levels of 0.8 mm/s as perceptible (See Figure 6). This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.

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[2] Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

[3] Berger P. R., & Associates Inc., Bradfordwoods, Pennsylvania, 15015, Nov 1980, Survey of Blasting Effects on Ground Water Supplies in Appalachia., Prepared for United States Department of Interior Bureau of Mines.

Indicated on Figure 6 is a blue solid line that indicates a ground vibration level of 12.5 mm/s and a green dotted line that indicates a ground vibration level of 6 mm/s. These are levels that are used in the evaluation.

Generally, people also assume that any vibration of a structure - windows or roofs rattling - will cause damage to the structure. An air blast is one of the causes of vibration of a structure and is the cause of nine out of ten complaints.

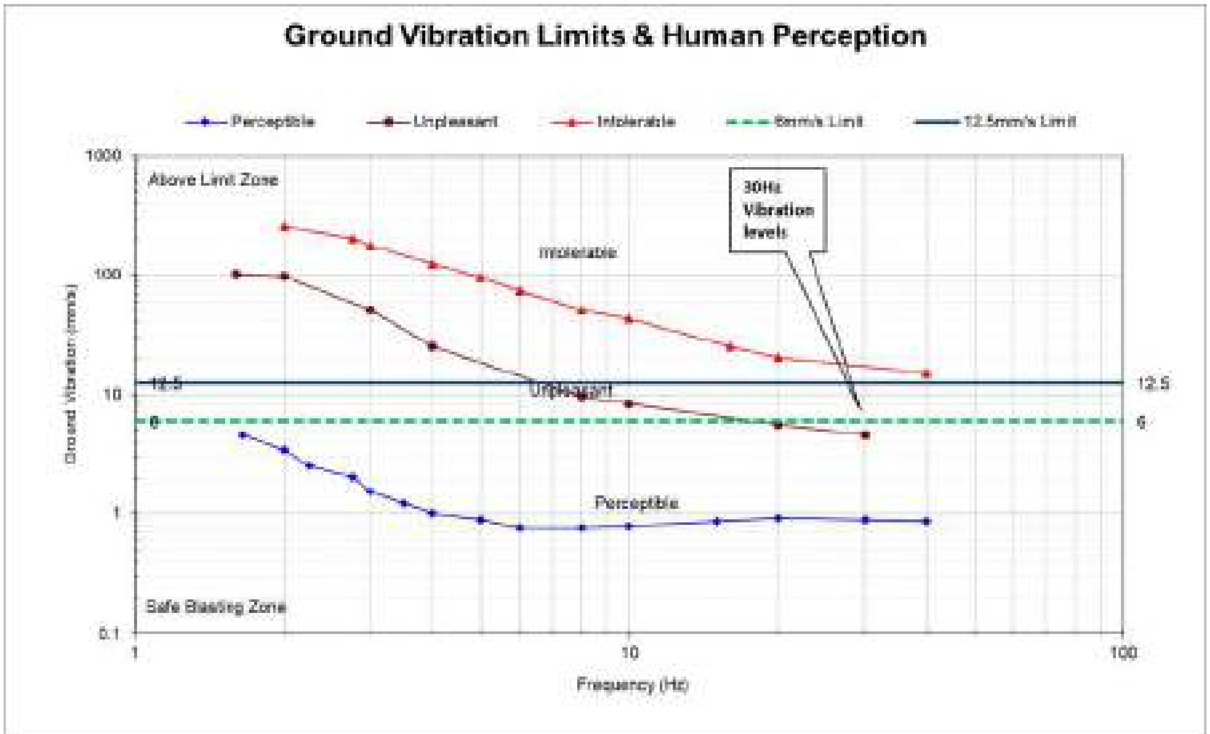


Figure 6: Ground Vibration and Human Perception

12.3 Air blast limitations on structures

Air blast or air-overpressure is a pressure wave generated from the blasting process. Air blast is measured as pressure in pascal (Pa) and reported as a decibel value (dBL). Air blast is normally associated with frequency levels less than 20 Hz, which is at the threshold for hearing. Air blast can be influenced by meteorological conditions such as, the final blast layout, timing, stemming, accessories used, blast covered by a layer of soil or not, etc. Air blast should not be confused with sound that is within the audible range (detected by the human ear). A blast does generate sound as well but for the purpose of possible damage capability we are only concerned with air blast in this report. The three main causes of air blasts can be observed as:

- Direct rock displacement at the blast; the air pressure pulse (APP).
- Vibrating ground some distance away from the blast; rock pressure pulse (RPP).
- Venting of blast holes or blowouts; the gas release pulse (GRP).

The general recommended limit for air blast currently applied in South Africa is 134dB. This is based on work done by the USBM. The USBM also indicates that the level is reduced to 128 dB in proximity of hospitals, schools and sensitive areas where people congregate. Based on work carried out by Siskind *et al.* (1980), monitored air blast amplitudes up to 135dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies. Persson *et al.* (1994) have published estimates of damage thresholds based on empirical data (Table 1). Levels given in Table 1 are at the point of measurement. The weakest points on a structure are the windows and ceilings.

Table 1: Damage Causing Levels for Air Blast

Level	Description
>130 dB	Resonant response of large surfaces (roofs, ceilings). Complaints start.
150 dB	Some windows break
170 dB	Most windows break
180 dB	Structural Damage

The following table showing summary of air blast limits applied in this report applicable:

Table 2: Air Blast Limits

Level	Description
<120 dB	Preferred levels to avoid complaints
120 dB	Bottom limit applied for start of complains
128 dB	USBM Proposed Limit for Schools and Hospitals
134 dB	Current RSA Limit

All attempts should be made to keep air blast levels from blasting operations well below 120dB where the public is of concern.

12.4 Air blast limitations and human perceptions

Considering human perceptions and the misunderstanding about ground vibration and air blast, BMC generally recommends that blasting be done in such a way that air blast levels are kept below 120dB. This will ensure fewer complaints regarding blasting operations. The effect of air blast on structures that startle people will also be reduced, which in turn reduces the reasons for complaints. It is the effect on structures (like rattling windows, doors or a large roof surface) that startles people. These effects are sometimes erroneously identified as ground vibration and considered to be damaging the structure.

In this report, initial limits for evaluating conditions have been set at 120dB, 120 dB to 134dB and greater than 134dB. The USBM limits for nuisance are 134dB.

12.5 Fly rock

Blasting practices require some movement of rock to facilitate the excavation process. The extent of movement is dependent on the scale and type of operation. For example, blasting activities at large coal mines are designed to cast the blasted material over a greater distance than in quarries or hard rock operations. The movement should be in the direction of the free face, and therefore the orientation of the blast is important. Material or elements travelling outside of this expected range would be considered to be fly rock. Figure 7 shows schematic of fly rock definitions.

Fly rock can be categorised as follows:

- Throw - the planned forward movement of rock fragments that form the muck pile within the blast zone.
- Fly rock - the undesired propulsion of rock fragments through the air or along the ground beyond the blast zone by the force of the explosion that is contained within the blast clearance (exclusion) zone. When using this definition, fly rock, while undesirable, is only a safety hazard if a breach of the blast clearance (exclusion) zone occurs.
- Wild fly rock - the unexpected propulsion of rock fragments that travels beyond the blast clearance (exclusion) zone when there is some abnormality in a blast or a rock mass.

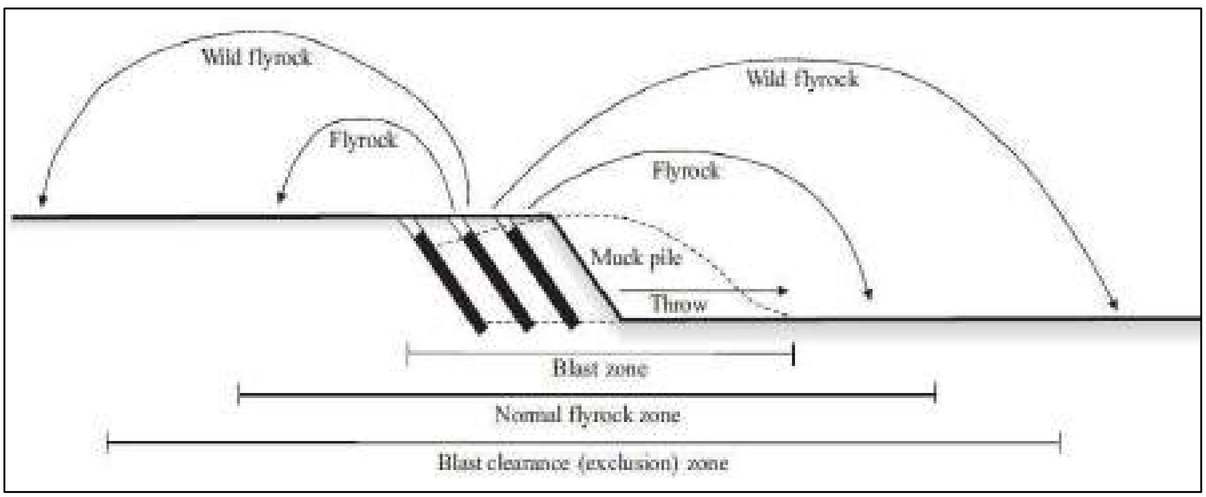


Figure 7: Schematic of fly rock terminology

Fly rock from blasting can result under the following conditions:
When burdens are too small, rock elements can be propelled out of the free face area of the blast.
When burdens are too large and movement of blast material is restricted and stemming length is not correct, rock elements can be forced upwards creating a crater forming fly rock.
If the stemming material is of poor quality or too little stemming material is applied, the stemming is ejected out of the blast hole, which can result in fly rock.
Stemming of correct type and length is required to ensure that explosive energy is efficiently used to its maximum and to control fly rock.

The occurrence of fly rock in any form will have impact if found to travel outside the safe boundary. If a road or structure or people or animals are within the safe boundary of a blast, irrespective of the possibility of fly rock or not, precautions should be taken to stop the traffic, remove people or animals for the period of the blast. The fact is that fly rock will cause damage to the road, vehicles or even death to people or animals. This safe boundary is determined by the appointed blaster or as per mine code of practice. BM&C uses a prediction calculation defined by the International Society of Explosives Engineers (ISEE) to assist with determining minimum distance.

12.6 Noxious Fumes

Explosives used in the mining environment are required to be oxygen balanced. Oxygen balance refers to the stoichiometry of the chemical reaction and the nature of gases produced from the detonation of the explosives. The creation of poisonous fumes such as nitrous oxides and carbon monoxide are particular undesirable. These fumes present themselves as red brown cloud after the blast has detonated. It has been reported that 10ppm to 20ppm can be mildly irritating. Exposure to 150 ppm or more (no time period given) has been reported to cause death from pulmonary oedema. It has been predicted that 50% lethality would occur following exposure to 174ppm for 1 hour. Anybody exposed must be taken to hospital for proper treatment.

Factors contributing to undesirable fumes are typically: poor quality control on explosive manufacture, damage to explosive, lack of confinement, insufficient charge diameter, excessive sleep time, water in blast holes, incorrect product used, or product not loaded properly, and specific types of rock/geology can also contribute to fumes.

12.7 Vibration impact on provincial and national roads

The influence of ground vibration on tarred roads are expected when levels is in the order of 150 mm/s and greater. Or when there is actual movement of ground when blasting is done too close to the road or subsidence is caused due to blasting operations. Normally 100 blast hole diameters are a minimum distance between structure and blast hole to prevent any cracks being formed into the surrounds of a blast hole. Crack forming is not restricted to this distance. Improper timing arrangements may also cause excessive back break and cracks further than expected. Fact remain that blasting must be controlled in the vicinity of roads. Air blast from blasting does not have influence on road surfaces. There is no record of influence on gravel roads due to ground vibration. The only time damage can be induced is when blasting is done next to the road and there is movement of ground. Fly rock will have greater influence on the road as damage from falling debris may impact on the road surface if no control on fly rock is considered.

12.8 Vibration will upset adjacent communities

The effects of ground vibration and air blast will have influence on people. These effects tend to create noises on structures in various forms and people react to these occurrences even at low levels. As with human perception given above – people will experience ground vibration at very low levels. These levels are well below damage capability for most structures.
Much work has also been done in the field of public relations in the mining industry. Most probably one aspect that stands out is “Promote good neighbour ship”. This is achieved through communication and more communication with the neighbours. Consider their concerns and address in a proper manner.

The first level of good practice is to avoid unnecessary problems. One problem that can be reduced is the public's reaction to blasting. Concern for a person's home, particularly where they own it, could be reduced by a scheme of precautionary, compensatory and other measures which offer guaranteed remedies without undue argument or excuse.

In general, it is also in an operator's financial interests not to blast where there is a viable alternative. Where there is a possibility of avoiding blasting, perhaps through new technology, this should be carefully considered in the light of environmental pressures. Historical precedent may not be a helpful guide to an appropriate decision.

Independent structural surveys are one way of ensuring good neighbour ship. There is a part of inherent difficulty in using surveys as the interpretation of changes in crack patterns that occur may be misunderstood. Cracks open and close with the seasonal changes of temperature, humidity and drainage, and numbers increase as buildings age. Additional actions need to be done in order to supplement the surveys as well.

The means of controlling ground vibration, overpressure and fly rock have many features in common and are used by the better operators. It is said that many of the practices also aid cost-effective production. Together these introduce a tighter regime which should reduce the incidence of fly rock and unusually high levels of ground vibration and overpressure. The measures include the need for the following:

- Correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charges which may increase vibration by a factor of two,
- The setting-out and drilling of blasts should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted,

- Correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental overcharging,
- Correct stemming will help control air blast and fly rock and will also aid the control of ground vibration. Controlling the length of the stemming column is important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used,
- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

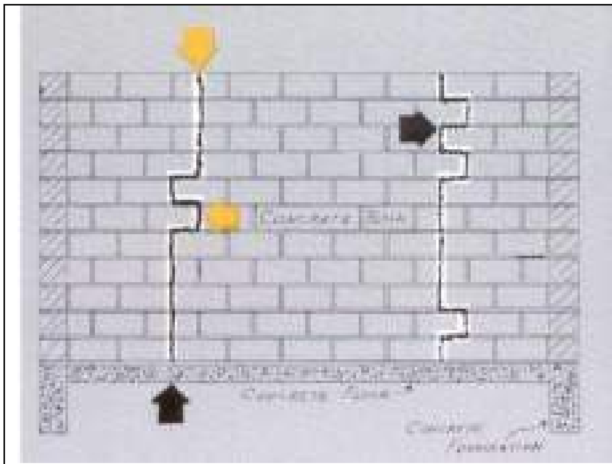
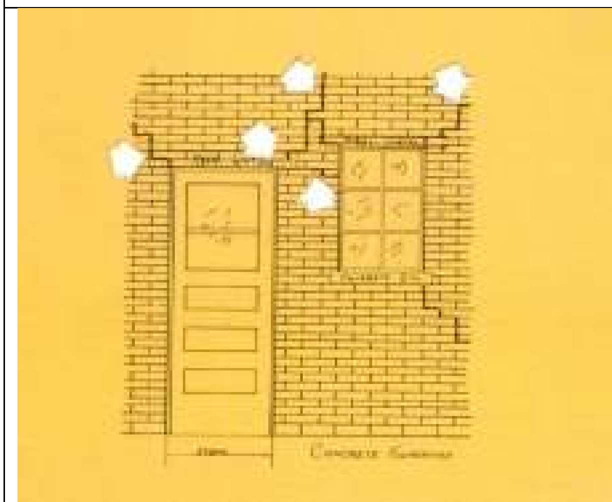
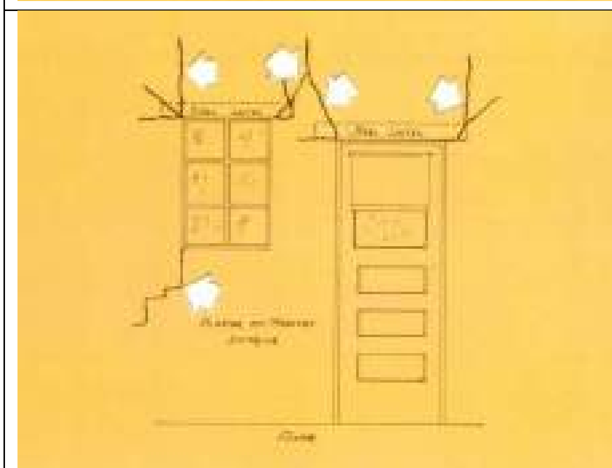
12.9 Cracking of houses and consequent devaluation

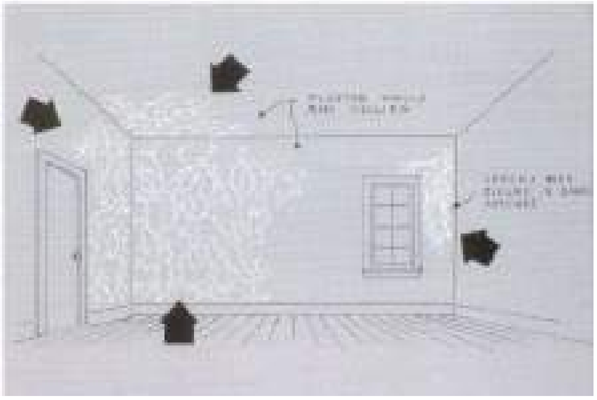
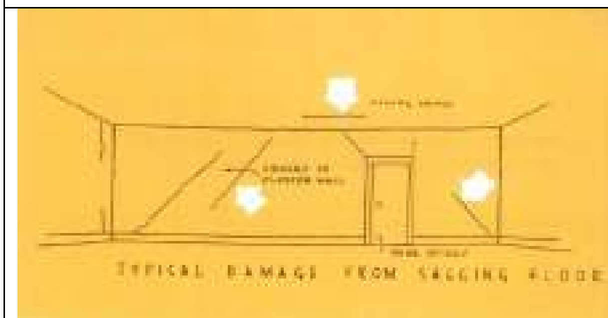
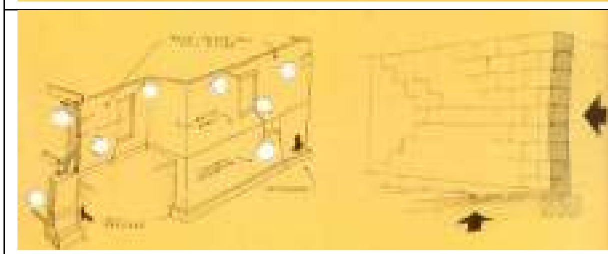
Houses in general have cracks. It is reported that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc. are more reason for cracks that have developed. Visual results of actual damage due to blasting operations are limited. There are cases where it did occur, and a result is shown in Figure 8 below. A typical X crack formation is observed.

Figure 8: Example of blast induced damage.

The table below with figures show illustrations of non-blasting damage that could be found.

Table 3: Examples of typical non-blasting cracks

	Cracks Resulting from Shrinkage of Concrete Blocks
	Typical Lintel Cracks
	Typical Lintel Cracks

	"Crazing" Cracks on Plaster
	Plaster Cracks Caused by Sagging Floors
	Cracks Resulting from Foundational Failure

Observing cracks in the form indicated in Figure 8 on a structure will certainly influence the value as structural damage has occurred. The presence of general vertical cracks or horizontal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Proper building standards are not always applied, and the general existence of cracks may be due to materials used. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. A property valuator will be required for this and I do believe that property value will include the total property and not just the house alone. Mining operations may not have influence to change the status quo of any property.

12.10 Water well Influence from Blasting Activities

Domestic, agricultural and monitoring boreholes are present around the proposed site. The author has not had much experience on the effect of blasting on water wells, but specific research was done and results from this research work are presented.

Case 1 looked at 36 case histories. Vibration levels up 50 mm/s were measured. The well yield and aquifer storage improved as the mining neared the wells, because of the opening of the fractures from loss of lateral confinement, not blasting. This is similar to how stress-relief fractures form. At one site, the process was reversed after the mine was backfilled. It was more likely the fractures were recompressed. It was stated that blasting may cause some temporary (transient) turbidity similar to those events that cause turbidity without blasting.

Such as:
1. Natural sloughing off inside of the well bore due to inherent rock instability. This can be accelerated by frequent over pumping. This is common to wells completed through considerable thickness of poorly consolidated and/or highly fractured clay stones and shales.
2. Significant rainfall events. The apertures of the shallow fractures that are intersected by a domestic well are commonly highly transmissive, thus will transmit substantial amounts of shallow flowing and rapidly recharging water. This water will commonly be turbid and can enter the well in high volumes. The lack of grouting of the near surface casing commonly allows this to happen. Also, if the top of the well is not grouted properly surface water can enter along the side of the casing and flow down the annulus.

The Berger Study observed ground-water impacts from manmade stress-release caused the rock mass removal during mining, but nothing from the blasting. The water quality and water levels were unaffected by the blasting. The “opening up” of the fractures lowered the ground-water levels by increasing the storage or porosity.

A study tested wells 50 m from a blast. Wells exhibited no quality or quantity impacts. Blast pressure surges ranged from 3 cm to 10 cm. Blasting caused no noticeable water table fluctuations and the hydraulic conductivity was unchanged. The pumping of the pit and encroachment of the high wall toward the wells dewatered the water table aquifer.

It may then be concluded from the studies researched as follows: Depending on the well construction, litho logic units encountered, and proximity to the blasting, it is believed that large shots could act as a catalyst for some well sloughing or collapse. However, the well would have to be inherently weak to begin with. The small to moderate shots will not show to impact wells. The minor water fluctuations attributed to blasting may cause a short-term turbidity problem, but do not pose any long-term problems. This fluctuation would not cause well collapse, as fluctuations from recharge and pumping occurs frequently. Long term changes to the well yield are more likely due to the opening of fractures from loss of lateral confinement. Short term dewatering of wells is caused by the opening of the fractures creating additional storage. A longer-term dewatering is caused by encroachment of the high wall and pumping of the pit water. The pit acts like a large pumping well. It is not believed that long term water quality problems will be caused by blasting alone. The possible exception is the introduction of residual nitrates, from the blasting materials, into the ground water system. This is only possible through wells that are hydro logically connected to a blasting site. Most of the long-term impacts on water quality are due to the mining (the breakup of the rocks). The influence will also be dependent if wells are beneath the excavation. Stress relief effects occur at shorter distances in this instance.

The results observed and levels recorded during research done showed that levels up to 50 mm/s or even higher in certain cases did not have any noticeable effect. It seems that safe conditions will be in the order of the 50 mm/s. In addition to this there are certain aspects that will need to be addressed prior to blasting operations.

13 Baseline Structure Profile

The site was reviewed using Google Earth imagery. All possible structures in a possible influence area were identified. Information sought during the review was to identify surface structures present in a 3500 m radius from the proposed open pit area, which will require consideration during modelling of blasting operations, e.g. houses, general structures, power lines, pipelines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the open pit area. The list includes structures and POI within the 3500 m boundary – see Table 5 below. A list of structure locations was required to determine the allowable ground vibration limits and air blast limits. Figure 4 shows an aerial view of the planned open pit area and surroundings with POIs. The type of POIs identified is grouped into different classes. These classes are indicated as "Classification" in Table 4. The classification used is a BM&C classification and does not relate to any standard or national or international code or practice. Table 4 shows the descriptions for the classifications used.

Table 4: POI Classification used

Class	Description
1	Rural Building and structures of poor construction
2	Private Houses and people sensitive areas
3	Office, High-rise buildings and Industrial buildings / Infrastructure
4	Ruins
5	Animal related installations and animal sensitive areas
6	Industrial Installations
7	Earth like structures – no surface structure
8	Heritage sites (buildings, infrastructure, activity)
9	Graves
10	Water Borehole
11	Water Resources Surface
12	Pipelines Buried
13	Powerlines / Telephone Lines / Towers
14	Road Infrastructure

Table 5: List of points of interest identified (WGS84 / UTM zone 33S)

Tag	Description	Classification	Y	X
1	Grave (1) - Site 312/847	9	485040.16	7647396.53
2	Graves (22) - Site 312/849	9	486088.90	7647335.48
3	Graves (100) - Site 312/893	9	486751.93	7654853.93
4	Graves (26) - Site 312/901	9	486373.89	7653427.34
5	Mine village - Site 312/900	2	490040.02	7651277.55
6	Mine adit - Site 312/899	3	488864.03	7650750.97
7	Borehole (BH1)	10	488994.16	7652581.75
8	Borehole (BH2)	10	488777.20	7652703.34
9	Borehole (BH3)	10	485683.96	7647753.71
10	Borehole (BH4)	10	485593.68	7647786.83
11	Borehole (BH5)	10	485687.20	7647609.83
12	Borehole (BH6)	10	486400.64	7647942.47
13	Borehole (BH8) - Inside Pit Area	10	487520.26	7651695.29
14	Borehole (BH9)	10	487881.52	7652890.86
15	Borehole (BH10)	10	488647.24	7653057.42
16	Borehole (BH11)	10	487625.96	7651883.51
17	Borehole (BH12)	10	487250.30	7653255.61
18	Reservoir	11	486018.48	7654339.41
19	Buildings/Structures (Uis Elephant Guesthouse)	2	486190.76	7653872.39
20	Guesthouse/Lodge	2	486450.11	7653879.57
21	Church	2	486459.52	7653705.24
22	Houses	2	486471.35	7653765.35
23	Filling Station	3	486437.24	7653584.39
24	Buildings/Structures (Brandberg Rest Camp)	2	486295.14	7653602.24
25	Shopping Centre	2	486213.00	7653510.22
26	Public (Riemvasmaak Community Conservancy)	2	486557.13	7653480.08
27	Buildings/Structures	2	485663.14	7653465.37
28	Reservoir	11	485277.95	7653632.96
29	Building/Structure	2	485641.20	7653978.58
30	Public (Campsite and B&B)	2	485757.18	7653923.23
31	Buildings/Structures	2	485735.26	7654116.21
32	Houses	2	485843.19	7653525.89
33	Houses	2	485809.61	7653671.51
34	Houses	2	485804.84	7653801.51
35	Houses	2	485964.04	7653898.89
36	Houses	2	486145.14	7653715.86
37	Houses	2	486041.32	7653584.29
38	Shopping Centre	2	486199.99	7653613.28
39	Swimming Pool	2	486300.17	7653642.23
40	Buildings/Structures	2	485945.18	7654128.39
41	Houses	2	486076.26	7653969.24
42	Houses	2	486238.85	7653940.13
43	Structure	2	486145.00	7653429.67
44	Runway	6	486569.65	7653265.31
45	Runway	6	485829.08	7651568.60

Tag	Description	Classification	Y	X
46	Buildings/Structures	2	486326.81	7652522.29
47	Heli Pad	6	486440.81	7652615.86
48	C35 Road	14	484459.35	7651762.75
49	M76 Road	14	483795.58	7650112.33
50	D1930 Road	14	489474.56	7651751.92
51	D1930 Road	14	489111.77	7650246.93
52	C36 Road	14	488026.92	7653058.17
53	D3714 Road	14	489086.49	7652612.46
54	Tailings Dam	6	487678.79	7653797.60
55	Buildings/Structures	2	488160.68	7653083.55
56	Buildings/Structures	2	488304.53	7653047.64
57	Buildings/Structures	2	488253.51	7653218.90
58	Industrial Structures (Mine)	3	488255.24	7652852.05
59	Sub Station	3	488358.19	7652705.39
60	Buildings/Structures	2	488547.88	7652858.87
61	Mine Buildings/Structures	3	488125.00	7652562.77
62	Mine Buildings/Structures	3	487940.07	7652222.50
63	Mine Buildings/Structures	3	487882.90	7652244.55
64	Mine Buildings/Structures	3	487923.27	7651940.61
65	Communication Tower	13	488571.92	7652470.68
66	Power Lines/Pylons - Inside Pit Area	13	487542.63	7651761.39
67	Power Lines/Pylons	13	487564.50	7651824.76
68	Power Lines/Pylons	13	487586.39	7651887.09
69	Power Lines/Pylons	13	487600.88	7651929.21
70	Power Lines/Pylons	13	487638.52	7651916.64
71	Power Lines/Pylons	13	487680.28	7651903.04
72	Power Lines/Pylons	13	487724.69	7651888.20
73	Power Lines/Pylons	13	487765.92	7651873.84
74	Power Lines/Pylons	13	487815.39	7651857.83
75	Power Lines/Pylons	13	487825.12	7651915.85
76	Power Lines/Pylons	13	487832.86	7651955.23
77	Power Lines/Pylons	13	487845.02	7652011.67
78	Power Lines/Pylons	13	487855.36	7652063.02
79	Power Lines/Pylons	13	487832.24	7652076.86
80	Power Lines/Pylons	13	487865.32	7652114.09
81	Power Lines/Pylons	13	487919.46	7652105.13
82	Stormwater Canal	6	487887.43	7652112.82
83	Stormwater Canal	6	487983.94	7652141.49
84	Stormwater Canal	6	488033.59	7652154.15
85	Stormwater Canal	6	488065.98	7652271.48
86	Stormwater Canal	6	488076.10	7652313.88
87	Stormwater Canal	6	488016.17	7652414.62
88	Stormwater Canal	6	488117.51	7652437.75
89	Stormwater Canal	6	488121.19	7652120.07
90	Stormwater Canal	6	488140.85	7651979.31
91	Stormwater Canal	6	488363.51	7651907.33

Tag	Description	Classification	Y	X
92	Reservoir	11	488520.33	7652017.26
93	Dams	11	489288.02	7652742.73
94	Buildings/Structures (Clinic)	2	489674.60	7652342.61
95	Ruins	4	489595.34	7652377.87
96	Reservoir	11	489685.01	7652473.81
97	Houses	2	489736.20	7652452.66
98	Houses	2	489713.49	7652639.08
99	Houses	2	489727.72	7652722.27
100	Houses	2	489807.92	7652557.69
101	Buildings/Structures	2	489897.63	7652640.33
102	Houses	2	490008.79	7652780.66
103	Houses	2	490326.45	7652783.03
104	Houses	2	490547.14	7652735.85
105	Houses	2	490555.14	7652555.87
106	Houses	2	490173.77	7652651.24
107	Houses	2	490192.71	7652519.39
108	Houses	2	490336.26	7652384.07
109	Houses	2	490004.44	7652556.88
110	Houses	2	490136.55	7652426.87
111	Houses	2	490178.08	7652248.28
112	Houses	2	490389.49	7652276.35
113	Houses	2	490219.59	7652215.55
114	Houses	2	490071.94	7652265.12
115	Houses	2	489941.33	7652385.63
116	Houses	2	490052.27	7652423.08
117	Houses	2	490279.83	7652693.67
118	Houses	2	490429.64	7652645.20
119	Buildings/Structures	2	490398.44	7652540.57
120	Buildings/Structures	2	490481.42	7652410.93
121	Buildings/Structures	2	490472.72	7652238.21
122	Houses	2	490377.56	7652171.61
123	Buildings/Structures	2	489857.63	7652501.89
124	Buildings/Structures	2	490223.45	7652334.24
125	Graveyard	9	492151.44	7651242.60
126	School	2	486497.33	7653642.88
127	Reservoir	11	489276.37	7650509.74
128	Old Sub Station	3	488125.04	7652048.29
129	Old Abandoned Mine Structures	3	487731.64	7652696.61
130	Old Abandoned Mine Structures	3	487551.21	7652087.32
131	Fibre Optical Cable	12	487850.63	7651959.03
132	Primary Crusher	6	487940.90	7651990.57

14 Blasting Operations

In order to evaluate the possible influence from blasting operations with regards to ground vibration, air blast and fly rock a planned blast design is required to determine possible influences.

Blasting is required for the overburden material and ore reserves.

This report concentrates on the drilling and blasting of the overburden. The overburden blasts are then considered as a worst-case scenario and is used as indicator of possible influence.

Blast design information was provided for the project. Using the data provided JKSimblast blast design software was used to design and simulate the blast. This designed blast was applied for the evaluation done in this report. The simulation of the blast provided the best prediction possible. Table 6 shows summary technical information of the blast designed. Figure 9 to Figure 14 shows the simulation outcomes.

Table 6: Blast design technical information

Blast Type	OB
Design	Design 01
Bench Height (m)	11
Blast Depth Min. (m)	10
Blast Depth Max. (m)	10
Include Sub Drill (Yes/No)	Yes
Sub-drill (m)	1.00
Explosive Type	Emulsion
Explo. Density (gr/cm3)	1.165
Diameter (mm)	89
Burden (m):	2.7
Spacing (m):	2.7
Pattern	
Average Depth (m)	11
Explosives Per B/H (incl. Sub drill) (kg)	68.9
Average Column Length (incl. Sub drill.)	9.5
Linear Charge (kg/m)	7.25
Stemming Length (m):	1.5
Powder Factor (kg/m3)	0.86

Figure 9: Blast Area with blastholes and depths

Figure 10: Blast Area with blastholes and charge per blasthole

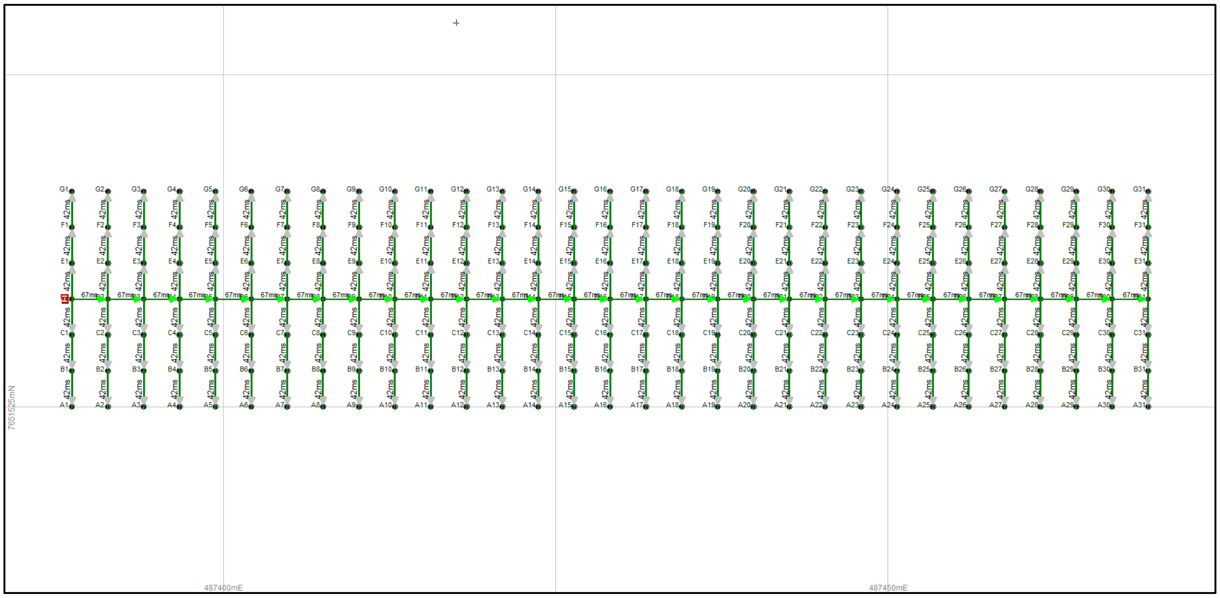


Figure 11: Blast Area with blastholes and blast timing

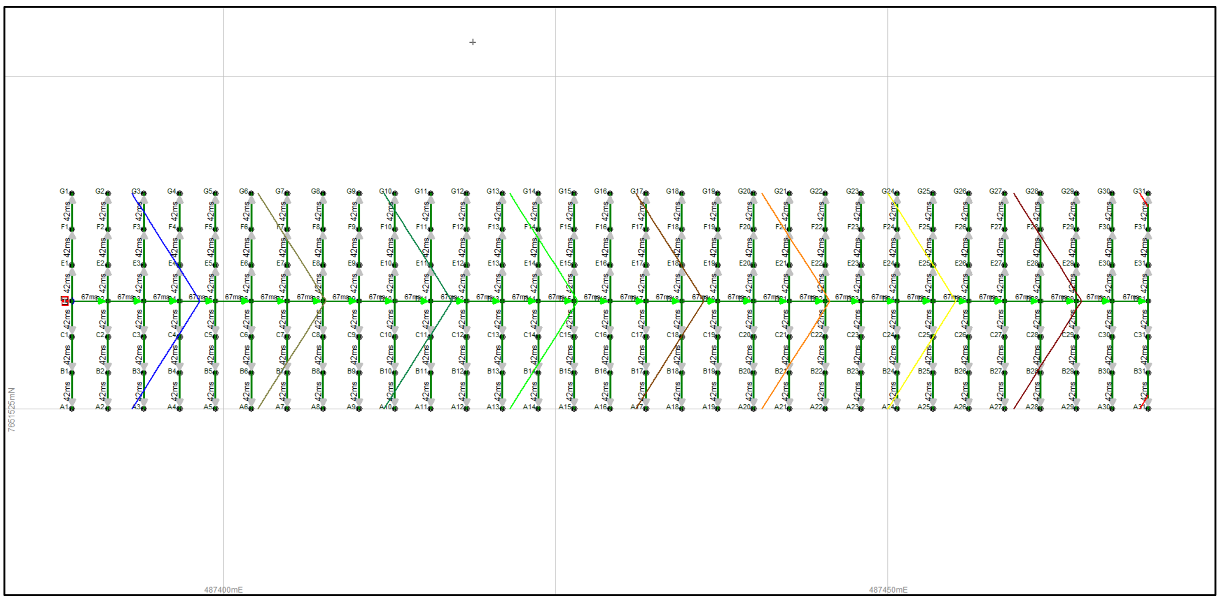


Figure 12: Blast simulated showing blast timing contours

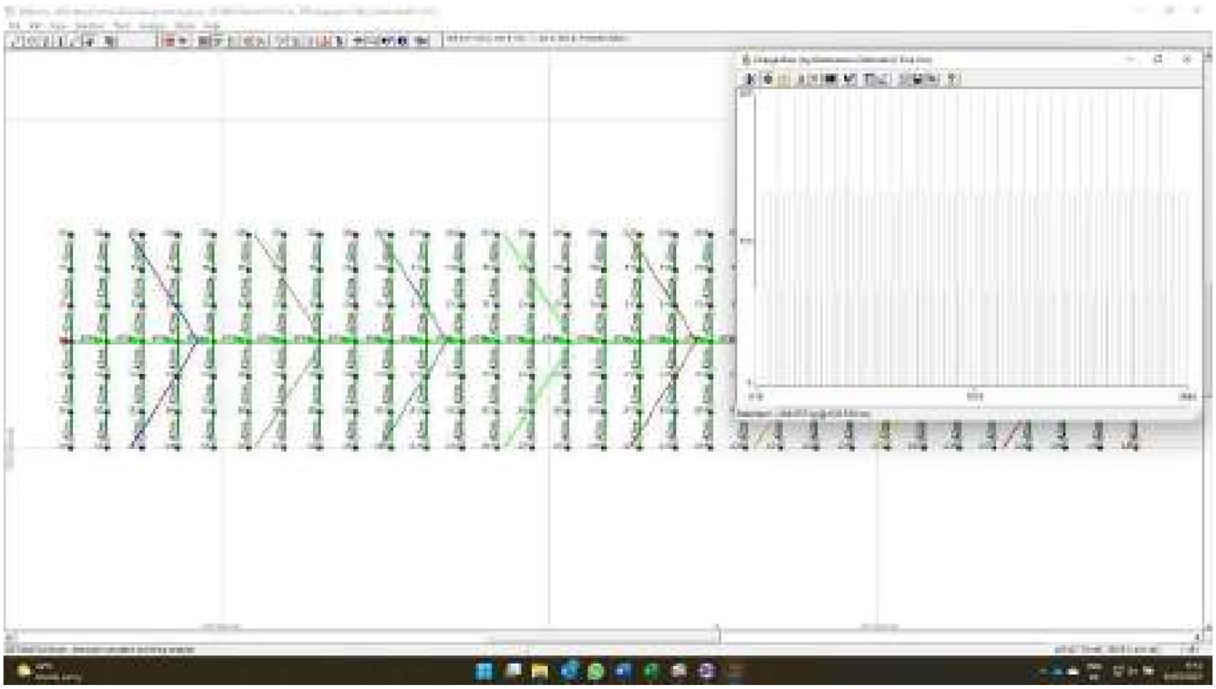


Figure 13: Blast simulated showing maximum charge mass per delay

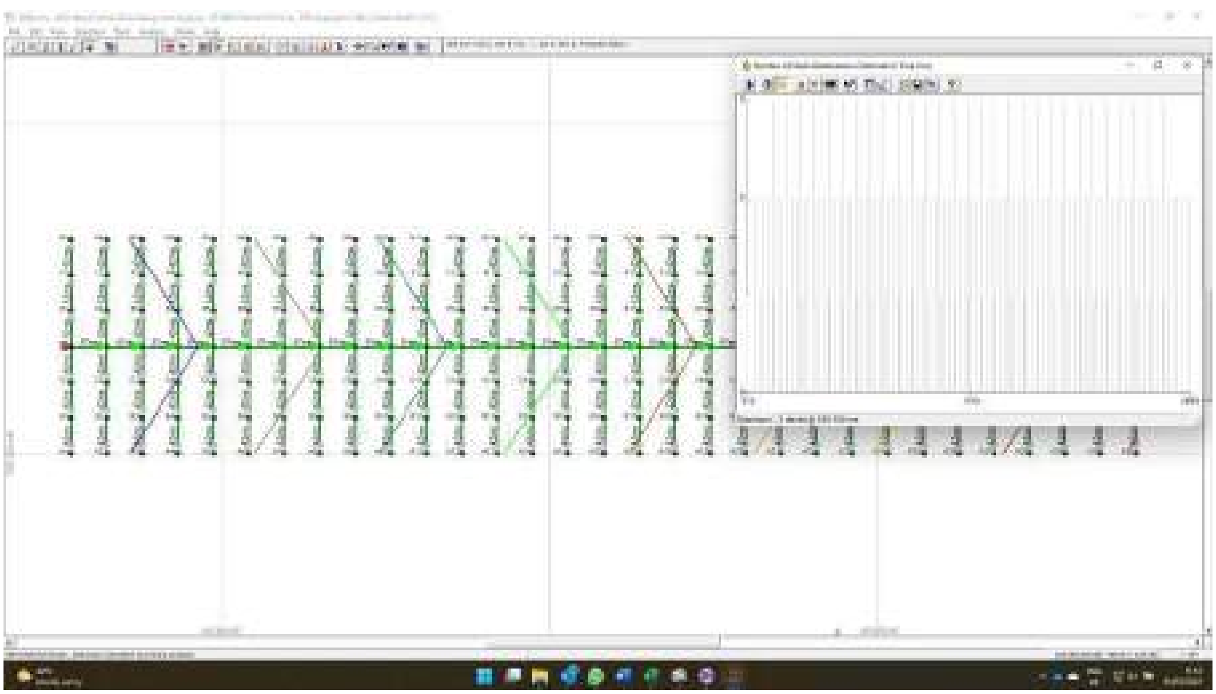


Figure 14: Blast simulated showing maximum number of blastholes per delay

The simulation work done provided information that is applied for predicting ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 89 mm diameter single blast hole and the maximum charge was determined from a shock tube timing. The maximum charge relates to the total number of blast holes that detonates simultaneously based on the blast layout and initiation timing of the blast. Thus, the maximum mass of explosives detonating at once. The minimum charge relates to 69 kg and the maximum charge relates to 207 kg. These values were applied in all predictions for ground vibration and air blast.

14.1 Ground Vibration

Predicting ground vibration and possible decay, a standard accepted mathematical process of scaled distance is used. The equation applied (Equation 1) uses the charge mass and distance with two site constants. The site constants are specific to a site where blasting is to be done. In the absence of measured values an acceptable standard set of constants is applied.

Equation 1:

$$PPV = a(\frac{D}{\sqrt{E}})^{-b}$$

Where:

PPV = Predicted ground vibration (mm/s)

a = Site constant

b = Site constant

D = Distance (m)

E = Explosive Mass (kg)

Applicable and accepted factors a and b for new operations is as follows:

Factors:

a = 1143

b = -1.65

Utilizing the abovementioned equation and the given factors, allowable levels for specific limits and expected ground vibration levels can then be calculated for various distances.

Review of the type of structures that are found within the possible influence zone of the proposed mining area and the limitations that may be applicable, different limiting levels of ground vibration will be required. This is due to the typical structures and installations observed surrounding the site and location of the project area. Structure types and qualities vary greatly and this calls for limits to be considered as follows: 6 mm/s, 12.5 mm/s levels and 25 mm/s at least.

Based on the designs presented on expected drilling and charging design, the following Table 7 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. The charge masses are 69 kg and 207 kg for the Pit area.

Table 7: Expected Ground Vibration at Various Distances from Charges Applied in this Study

No.	Distance (m)	Expected PPV (mm/s) for 69 kg Charge	Expected PPV (mm/s) for 207 kg Charge
1	50.0	59.1	146.4
2	100.0	30.3	75.0

No.	Distance (m)	Expected PPV (mm/s) for 69 kg Charge	Expected PPV (mm/s) for 207 kg Charge
3	150.0	9.7	23.9
4	200.0	6.0	14.9
5	250.0	4.2	10.3
6	300.0	3.1	7.6
7	400.0	1.9	4.7
8	500.0	1.3	3.3
9	600.0	1.0	2.4
10	700.0	0.8	1.9
11	800.0	0.6	1.5
12	900.0	0.5	1.2
13	1000.0	0.4	1.0
14	1250.0	0.3	0.7
15	1500.0	0.2	0.5
16	1750.0	0.2	0.4
17	2000.0	0.1	0.3
18	2500.0	0.1	0.2
19	3000.0	0.1	0.2
20	3500.0	0.1	0.0

14.2 Air blast

The prediction of air blast as a pre-operational effect is difficult to define exactly. There are many variables that have influence on the outcome of air blast. Air blast is the direct result from the blast process, although influenced by meteorological conditions, wind strength and direction, the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result. Air blast is also an aspect that can be controlled to a great degree by applying basic rules.
In most cases mainly an indication of typical levels can be obtained. The indication of levels or the prediction of air blast in this report is used to predefine possible indicators of concern.

Standard accepted prediction equations are applied for the prediction of air blast. A standard cube root scaling prediction formula is applied for air blast predictions. The following Equation 2 was used to calculate possible air blast values in millibar. This equation does not take temperature or any weather conditions into account.

Equation 2:

$$P = \mathrm{A} \times \left(\frac{\mathrm{D}}{\mathrm{E}^{\frac{1}{3}}}\right)^{-B}$$

Where:

P = Air blast level (mB)

D = Distance from source (m)

E = Maximum charge mass per delay (kg)

A = Constant - (14.3)

B = Constant – (-0.71)

The constants for A and B were then selected according to the information as provided in Figure 15 below. Various types of mining operations are expected to yield different results. The information provided in Figure 15 is based on detailed research that was conducted for each of the different types of mining environments. In this report, the data for "Metal Mine" was applied in the prediction or air blast.

Air Overpressure Prediction Equations

Blasting	Metric Equations mb	U.S. Equations psi	Statistical Type	Source
Open air (no confinement)	$P = 3589 \times SD_3^{-1.38}$	$P = 187 \times SD_3^{-1.38}$	Best Fit	Perkins
Coal mines (parting)	$P = 2596 \times SD_3^{-1.62}$	$P = 169 \times SD_3^{-1.62}$	Best Fit	USBM RI 8485
Coal mines (highwall)	$P = 5.37 \times SD_3^{-0.79}$	$P = 0.162 \times SD_3^{-0.79}$	Best Fit	USBM RI 8485
Quarry face	$P = 37.1 \times SD_3^{-0.97}$	$P = 1.32 \times SD_3^{-0.97}$	Best Fit	USBM RI 8485
Metal Mine	$P = 14.3 \times SD_3^{-0.71}$	$P = 0.401 \times SD_3^{-0.71}$	Best Fit	USBM RI 8485
Construction (average)	$P = 24.8 \times SD_3^{-1.1}$	$P = 1 \times SD_3^{-1.1}$	Best Fit	Oriard (2005)
Construction (highly confined)	$P = 2.48 \times SD_3^{-1.1}$	$P = 0.1 \times SD_3^{-1.1}$	Best Fit	Oriard (2005)
Buried (total confinement)	$P = 1.73 \times SD_3^{-0.96}$	$P = 0.061 \times SD_3^{-0.96}$	Best Fit	USBM RI 8485

Table 26.7 - Air overpressure prediction equations.

Figure 15: Proposed prediction equations

The air pressure calculated in Equation 2 is converted to decibels in Equation 3. The reporting of air blast in the decibel scale is more readily accepted in the mining industry.

Equation 3:

$$p_s = 20 \text{ x} \log \frac{P}{P_o}$$

Where:

p_s = Air blast level (dB)

P = Air blast level (Pa (mB x 100))

P_o = Reference Pressure (2 x 10^{-5} Pa)

Although the above equation was applied for prediction of air blast levels, additional measures are also recommended to ensure that air blast and associated fly-rock possibilities are minimized as best possible.

As discussed earlier the prediction of air blast is very subjective. Following in Table 8 below is a summary of values predicted according to Equation 2.

Table 8: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) for 69 kg Charge	Air blast (dB) for 207 kg Charge
1	50.0	141.6	143.9
2	100.0	139.1	141.4
3	150.0	134.8	137.1
4	200.0	133.1	135.3
5	250.0	131.7	134.0
6	300.0	130.6	132.8
7	400.0	128.8	131.1
8	500.0	127.4	129.7
9	600.0	126.3	128.6
10	700.0	125.3	127.6
11	800.0	124.5	126.8
12	900.0	123.8	126.1
13	1000.0	123.1	125.4
14	1250.0	121.8	124.0
15	1500.0	120.7	122.9
16	1750.0	119.7	122.0
17	2000.0	118.9	121.1
18	2500.0	117.5	119.8
19	3000.0	116.4	118.6
20	3500.0	115.4	111.9

15 Operational Phase: Impact Assessment and Mitigation Measures

The area surrounding the proposed mining area was reviewed for structures, traffic, roads, human interface, animals' interface etc. Various installations and structures were observed. These are listed in Table 5. This section concentrates on the outcome of modelling the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces. In evaluation, the charge mass scenarios selected as indicated in section 0 is considered with regards to ground vibration and air blast.

Ground vibration and air blast was calculated from the edge of the pit outline and modelled accordingly. Blasting further away from the pit edge will certainly have lesser influence on the surroundings. A worst case is then applicable with calculation from pit edge. As explained previously reference is only made to some structures and these references covers the extent of all structures surrounding the mine.

The following aspects with comments are addressed for each of the evaluations done:

- Ground Vibration Modelling Results
- Ground Vibration and human perception
- Vibration impact on national and provincial road
- Vibration will upset adjacent communities
- Cracking of houses and consequent devaluation

- Air blast Modelling Results
- Impact of fly rock
- Noxious fumes Influence Results

Please note that this analysis does not take geology, topography or actual final drill and blast pattern into account. The data is based on good practise applied internationally and considered very good estimates based on the information provided and supplied in this document.

15.1 Review of expected ground vibration

Presented herewith are the expected ground vibration level contours and discussion of relevant influences. Expected ground vibration levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns and human perception. Tables are provided for each of the different charge models done with regards to:

- "Tag" No. is the number corresponding to the POI figures.
- "Description" indicates the type of the structure.
- "Distance" is the distance between the structure and edge of the pit area.
- "Specific Limit" is the maximum limit for ground vibration at the specific structure or installation.
- "Predicted PPV (mm/s)" is the calculated ground vibration at the structure.
- The "Structure Response @ 10Hz and Human Tolerance @ 30Hz" indicates the possible concern and if there is any concern for structural damage or potential negative human perception, respectively. Indicators used are "perceptible"," unpleasant", "intolerable" which stems from the human perception information given and indicators such as "high" or "low" is given for the possibility of damage to a structure. Levels below 0.76 mm/s could be considered to have negligible possibility of influence.

Ground vibration is calculated and modelled for the pit area at the minimum and maximum charge mass at specific distances from the opencast mining area. The charge masses applied are according to blast designs discussed in Section 15. These levels are then plotted and overlaid with current mining plans to observe possible influences at structures identified. Structures or POI's for consideration are also plotted in this model. Ground vibration predictions were done considering distances ranging from 50 m to 3500 m around the opencast mining area.

The simulation provided shows ground vibration contours only for a limited number of levels. The levels used are considered the basic limits that will be applicable for the type of structures observed surrounding the pit area. These levels are: 6 mm/s, 12.5 mm/s, 25 mm/s and 50 mm/s. This enables immediate review of possible concerns that may be applicable to any of the privately-owned structures, social gathering areas or sensitive installations.

Data is provided as follows: Vibration contours; a table with predicted ground vibration values and evaluation for each POI. Additional colour codes used in the tables are as follows:

Structure Evaluations:
Vibration levels higher than proposed limit applicable to Structures / Installations is coloured "Red"
People's Perception Evaluation:
Vibration levels indicated as Intolerable on human perception scale is coloured "Red"
Vibration levels indicated as Unpleasant on human perception scale is coloured "Mustard"
Vibration levels indicated as Perceptible on human perception scale is coloured "Light Green"
POI's that are found inside the pit area is coloured "Olive Green"

Simulations for expected ground vibration levels from minimum and maximum charge mass are presented below.

15.1.1 Ground vibration minimum charge mass per delay – 69 kg

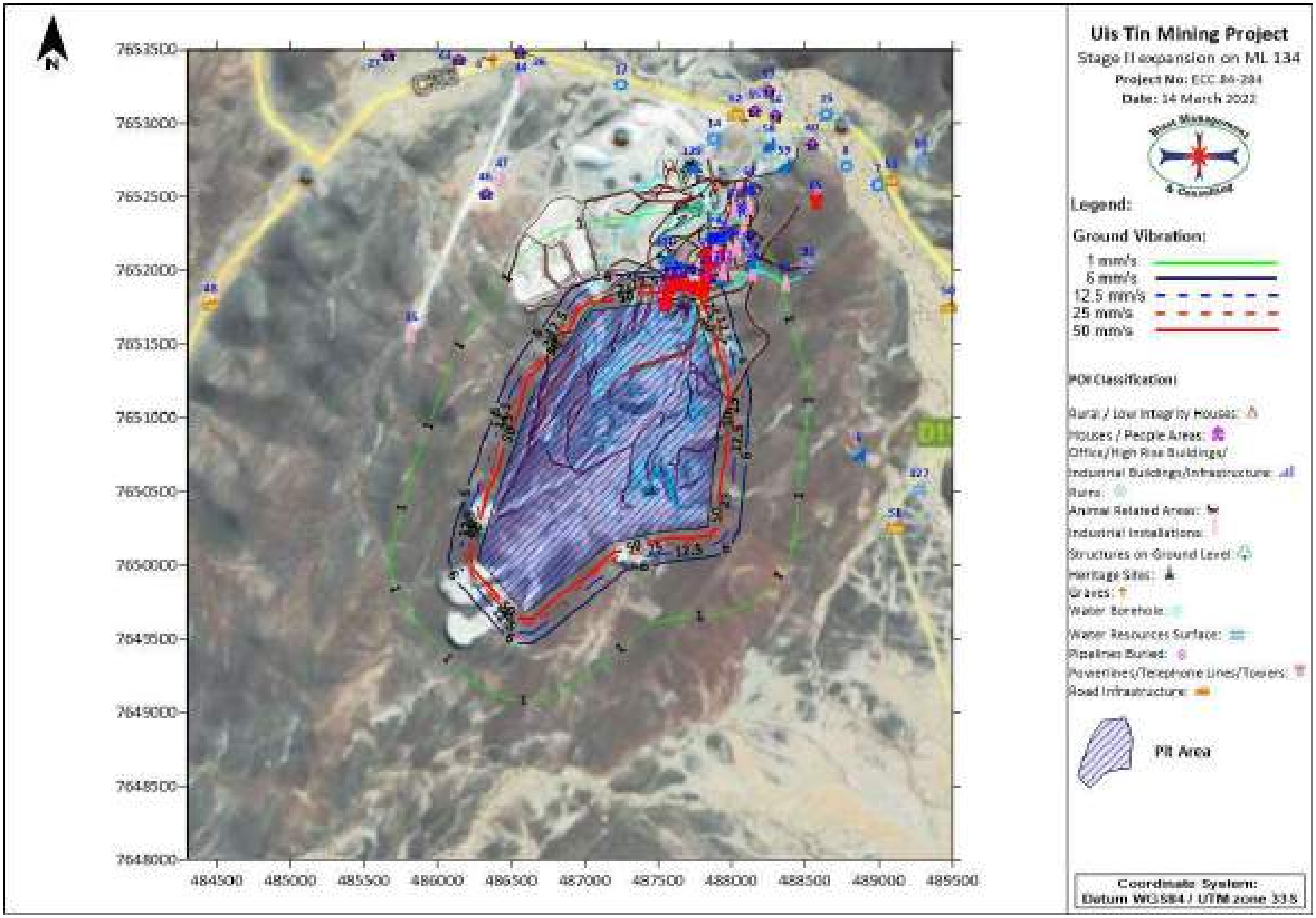


Figure 16: Ground vibration influence from minimum charge per delay

Table 9: Ground vibration evaluation for minimum charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Grave (1) - Site 312/847	50	2761	69	0.1	Acceptable	N/A
2	Graves (22) - Site 312/849	50	2397	69	0.1	Acceptable	N/A
3	Graves (100) - Site 312/893	50	3138	69	0.1	Acceptable	N/A
4	Graves (26) - Site 312/901	50	1830	69	0.2	Acceptable	N/A
5	Mine village - Site 312/900	12.5	2117	69	0.1	Acceptable	Too Low
6	Mine adit - Site 312/899	50	972	69	0.4	Acceptable	Too Low
7	Borehole (BH1)	50	1470	69	0.2	Acceptable	N/A
8	Borehole (BH2)	50	1367	69	0.3	Acceptable	N/A
9	Borehole (BH3)	50	2130	69	0.1	Acceptable	N/A
10	Borehole (BH4)	50	2141	69	0.1	Acceptable	N/A
11	Borehole (BH5)	50	2260	69	0.1	Acceptable	N/A
12	Borehole (BH6)	50	1747	69	0.2	Acceptable	N/A
13	Borehole (BH8) - Inside Pit Area	50	-	69	-	-	-
14	Borehole (BH9)	50	1092	69	0.4	Acceptable	N/A
15	Borehole (BH10)	50	1543	69	0.2	Acceptable	N/A
16	Borehole (BH11)	50	74	69	30.7	Acceptable	N/A
17	Borehole (BH12)	50	1486	69	0.2	Acceptable	N/A
18	Reservoir	50	2809	69	0.1	Acceptable	N/A
19	Buildings/Structures (Uis Elephant Guesthouse)	12.5	2311	69	0.1	Acceptable	Too Low
20	Guesthouse/Lodge	12.5	2235	69	0.1	Acceptable	Too Low
21	Church	12.5	2065	69	0.1	Acceptable	Too Low
22	Houses	12.5	2120	69	0.1	Acceptable	Too Low
23	Filling Station	12.5	1957	69	0.1	Acceptable	Too Low
24	Buildings/Structures (Brandberg Rest Camp)	12.5	2022	69	0.1	Acceptable	Too Low
25	Shopping Centre	50	1969	69	0.1	Acceptable	Too Low
26	Public (Riemvasmaak Community Conservancy)	25	1822	69	0.2	Acceptable	Too Low
27	Buildings/Structures	12.5	2220	69	0.1	Acceptable	Too Low
28	Reservoir	50	2597	69	0.1	Acceptable	N/A
29	Building/Structure	12.5	2654	69	0.1	Acceptable	Too Low
30	Public (Campsite and B&B)	25	2546	69	0.1	Acceptable	Too Low
31	Buildings/Structures	12.5	2725	69	0.1	Acceptable	Too Low
32	Houses	12.5	2163	69	0.1	Acceptable	Too Low
33	Houses	12.5	2304	69	0.1	Acceptable	Too Low
34	Houses	12.5	2417	69	0.1	Acceptable	Too Low
35	Houses	12.5	2427	69	0.1	Acceptable	Too Low
36	Houses	12.5	2185	69	0.1	Acceptable	Too Low
37	Houses	12.5	2112	69	0.1	Acceptable	Too Low
38	Shopping Centre	50	2069	69	0.1	Acceptable	Too Low
39	Swimming Pool	25	2057	69	0.1	Acceptable	Too Low
40	Buildings/Structures	12.5	2643	69	0.1	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
41	Houses	12.5	2444	69	0.1	Acceptable	Too Low
42	Houses	12.5	2358	69	0.1	Acceptable	Too Low
43	Structure	12.5	1927	69	0.1	Acceptable	Too Low
44	Runway	150	1612	69	0.2	Acceptable	Too Low
45	Runway	150	912	69	0.5	Acceptable	Too Low
46	Buildings/Structures	12.5	1070	69	0.4	Acceptable	Too Low
47	Heli Pad	150	1075	69	0.4	Acceptable	Too Low
48	C35 Road	150	2265	69	0.1	Acceptable	N/A
49	M76 Road	150	2483	69	0.1	Acceptable	N/A
50	D1930 Road	150	1650	69	0.2	Acceptable	N/A
51	D1930 Road	150	1269	69	0.3	Acceptable	N/A
52	C36 Road	150	1284	69	0.3	Acceptable	N/A
53	D3714 Road	150	1565	69	0.2	Acceptable	N/A
54	Tailings Dam	25	1982	69	0.1	Acceptable	Too Low
55	Buildings/Structures	12.5	1344	69	0.3	Acceptable	Too Low
56	Buildings/Structures	12.5	1362	69	0.3	Acceptable	Too Low
57	Buildings/Structures	12.5	1502	69	0.2	Acceptable	Too Low
58	Industrial Structures (Mine)	25	1164	69	0.3	Acceptable	Too Low
59	Sub Station	25	1089	69	0.4	Acceptable	Too Low
60	Buildings/Structures	12.5	1324	69	0.3	Acceptable	Too Low
61	Mine Buildings/Structures	25	847	69	0.6	Acceptable	Too Low
62	Mine Buildings/Structures	25	460	69	1.5	Acceptable	Perceptible
63	Mine Buildings/Structures	25	461	69	1.5	Acceptable	Perceptible
64	Mine Buildings/Structures	25	223	69	5.0	Acceptable	Perceptible
65	Communication Tower	25	1061	69	0.4	Acceptable	N/A
66	Power Lines/Pylons - Inside Pit Area	75	-	69	-	-	-
67	Power Lines/Pylons	75	25	69	189.6	Problematic	N/A
68	Power Lines/Pylons	75	83	69	25.5	Acceptable	N/A
69	Power Lines/Pylons	75	123	69	13.4	Acceptable	N/A
70	Power Lines/Pylons	75	105	69	17.3	Acceptable	N/A
71	Power Lines/Pylons	75	87	69	23.5	Acceptable	N/A
72	Power Lines/Pylons	75	78	69	28.2	Acceptable	N/A
73	Power Lines/Pylons	75	72	69	32.5	Acceptable	N/A
74	Power Lines/Pylons	75	87	69	23.7	Acceptable	N/A
75	Power Lines/Pylons	75	136	69	11.3	Acceptable	N/A
76	Power Lines/Pylons	75	174	69	7.6	Acceptable	N/A
77	Power Lines/Pylons	75	229	69	4.8	Acceptable	N/A
78	Power Lines/Pylons	75	280	69	3.4	Acceptable	N/A
79	Power Lines/Pylons	75	285	69	3.3	Acceptable	N/A
80	Power Lines/Pylons	75	331	69	2.6	Acceptable	N/A
81	Power Lines/Pylons	75	347	69	2.4	Acceptable	N/A
82	Stormwater Canal	150	339	69	2.5	Acceptable	N/A
83	Stormwater Canal	150	412	69	1.8	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
84	Stormwater Canal	150	452	69	1.6	Acceptable	N/A
85	Stormwater Canal	150	566	69	1.1	Acceptable	N/A
86	Stormwater Canal	150	607	69	1.0	Acceptable	N/A
87	Stormwater Canal	150	667	69	0.8	Acceptable	N/A
88	Stormwater Canal	150	734	69	0.7	Acceptable	N/A
89	Stormwater Canal	150	490	69	1.4	Acceptable	N/A
90	Stormwater Canal	150	431	69	1.7	Acceptable	N/A
91	Stormwater Canal	150	622	69	0.9	Acceptable	N/A
92	Reservoir	50	803	69	0.6	Acceptable	N/A
93	Dams	50	1805	69	0.2	Acceptable	N/A
94	Buildings/Structures (Clinic)	12.5	2002	69	0.1	Acceptable	Too Low
95	Ruins	6	1936	69	0.1	Acceptable	N/A
96	Reservoir	50	2051	69	0.1	Acceptable	N/A
97	Houses	12.5	2093	69	0.1	Acceptable	Too Low
98	Houses	12.5	2137	69	0.1	Acceptable	Too Low
99	Houses	12.5	2183	69	0.1	Acceptable	Too Low
100	Houses	12.5	2195	69	0.1	Acceptable	Too Low
101	Buildings/Structures	12.5	2308	69	0.1	Acceptable	Too Low
102	Houses	12.5	2464	69	0.1	Acceptable	Too Low
103	Houses	12.5	2759	69	0.1	Acceptable	Too Low
104	Houses	12.5	2951	69	0.1	Acceptable	Too Low
105	Houses	12.5	2907	69	0.1	Acceptable	Too Low
106	Houses	12.5	2571	69	0.1	Acceptable	Too Low
107	Houses	12.5	2549	69	0.1	Acceptable	Too Low
108	Houses	12.5	2650	69	0.1	Acceptable	Too Low
109	Houses	12.5	2380	69	0.1	Acceptable	Too Low
110	Houses	12.5	2469	69	0.1	Acceptable	Too Low
111	Houses	12.5	2461	69	0.1	Acceptable	Too Low
112	Houses	12.5	2673	69	0.1	Acceptable	Too Low
113	Houses	12.5	2493	69	0.1	Acceptable	Too Low
114	Houses	12.5	2364	69	0.1	Acceptable	Too Low
115	Houses	12.5	2270	69	0.1	Acceptable	Too Low
116	Houses	12.5	2387	69	0.1	Acceptable	Too Low
117	Houses	12.5	2685	69	0.1	Acceptable	Too Low
118	Houses	12.5	2812	69	0.1	Acceptable	Too Low
119	Buildings/Structures	12.5	2752	69	0.1	Acceptable	Too Low
120	Buildings/Structures	12.5	2797	69	0.1	Acceptable	Too Low
121	Buildings/Structures	12.5	2742	69	0.1	Acceptable	Too Low
122	Houses	12.5	2633	69	0.1	Acceptable	Too Low
123	Buildings/Structures	12.5	2223	69	0.1	Acceptable	Too Low
124	Buildings/Structures	12.5	2528	69	0.1	Acceptable	Too Low
125	Graveyard	50	4226	69	0.0	Acceptable	N/A
126	School	25	1995	69	0.1	Acceptable	Too Low
127	Reservoir	50	1407	69	0.2	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
128	Old Sub Station	25	450	69	1.6	Acceptable	N/A
129	Old Abandoned Mine Structures	25	882	69	0.5	Acceptable	N/A
130	Old Abandoned Mine Structures	25	287	69	3.3	Acceptable	N/A
131	Fibre Optical Cable	50	186	69	6.8	Acceptable	N/A
132	Primary Crusher	200	269	69	3.7	Acceptable	N/A

15.1.2 Ground vibration maximum charge mass per delay – 207 kg

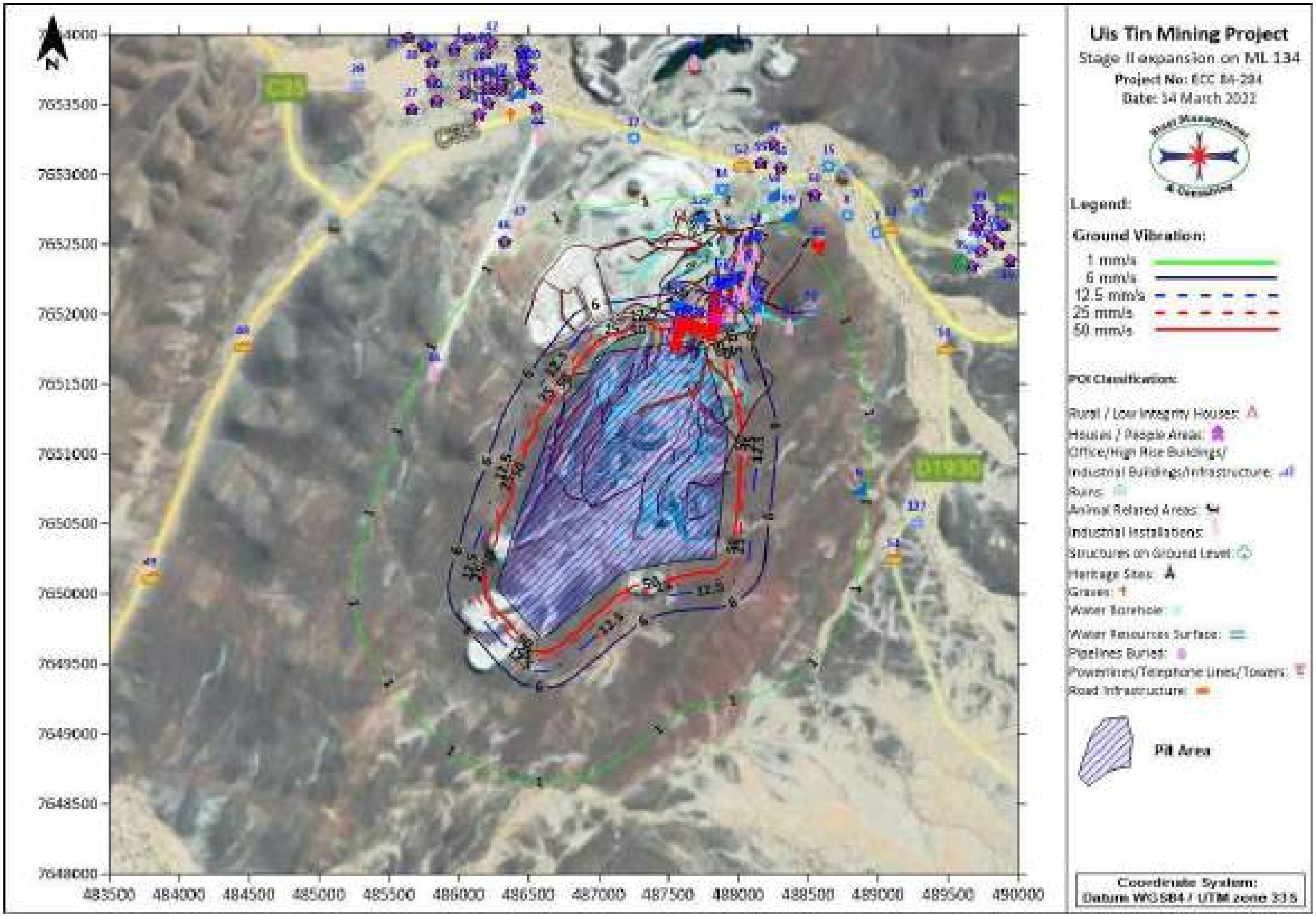


Figure 17: Ground vibration influence from maximum charge per delay

Table 10: Ground vibration evaluation for maximum charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Grave (1) - Site 312/847	50	2761	207	0.2	Acceptable	N/A
2	Graves (22) - Site 312/849	50	2397	207	0.2	Acceptable	N/A
3	Graves (100) - Site 312/893	50	3138	207	0.2	Acceptable	N/A
4	Graves (26) - Site 312/901	50	1830	207	0.4	Acceptable	N/A
5	Mine village - Site 312/900	12.5	2117	207	0.3	Acceptable	Too Low
6	Mine adit - Site 312/899	50	972	207	1.1	Acceptable	Perceptible
7	Borehole (BH1)	50	1470	207	0.6	Acceptable	N/A
8	Borehole (BH2)	50	1367	207	0.6	Acceptable	N/A
9	Borehole (BH3)	50	2130	207	0.3	Acceptable	N/A
10	Borehole (BH4)	50	2141	207	0.3	Acceptable	N/A
11	Borehole (BH5)	50	2260	207	0.3	Acceptable	N/A
12	Borehole (BH6)	50	1747	207	0.4	Acceptable	N/A
13	Borehole (BH8) - Inside Pit Area	50	-	207	-	-	-
14	Borehole (BH9)	50	1092	207	0.9	Acceptable	N/A
15	Borehole (BH10)	50	1543	207	0.5	Acceptable	N/A
16	Borehole (BH11)	50	74	207	76.0	Problematic	N/A
17	Borehole (BH12)	50	1486	207	0.5	Acceptable	N/A
18	Reservoir	50	2809	207	0.2	Acceptable	N/A
19	Buildings/Structures (Uis Elephant Guesthouse)	12.5	2311	207	0.3	Acceptable	Too Low
20	Guesthouse/Lodge	12.5	2235	207	0.3	Acceptable	Too Low
21	Church	12.5	2065	207	0.3	Acceptable	Too Low
22	Houses	12.5	2120	207	0.3	Acceptable	Too Low
23	Filling Station	12.5	1957	207	0.3	Acceptable	Too Low
24	Buildings/Structures (Brandberg Rest Camp)	12.5	2022	207	0.3	Acceptable	Too Low
25	Shopping Centre	50	1969	207	0.3	Acceptable	Too Low
26	Public (Riemvasmaak Community Conservancy)	25	1822	207	0.4	Acceptable	Too Low
27	Buildings/Structures	12.5	2220	207	0.3	Acceptable	Too Low
28	Reservoir	50	2597	207	0.2	Acceptable	N/A
29	Building/Structure	12.5	2654	207	0.2	Acceptable	Too Low
30	Public (Campsite and B&B)	25	2546	207	0.2	Acceptable	Too Low
31	Buildings/Structures	12.5	2725	207	0.2	Acceptable	Too Low
32	Houses	12.5	2163	207	0.3	Acceptable	Too Low
33	Houses	12.5	2304	207	0.3	Acceptable	Too Low
34	Houses	12.5	2417	207	0.2	Acceptable	Too Low
35	Houses	12.5	2427	207	0.2	Acceptable	Too Low
36	Houses	12.5	2185	207	0.3	Acceptable	Too Low
37	Houses	12.5	2112	207	0.3	Acceptable	Too Low
38	Shopping Centre	50	2069	207	0.3	Acceptable	Too Low
39	Swimming Pool	25	2057	207	0.3	Acceptable	Too Low
40	Buildings/Structures	12.5	2643	207	0.2	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
41	Houses	12.5	2444	207	0.2	Acceptable	Too Low
42	Houses	12.5	2358	207	0.3	Acceptable	Too Low
43	Structure	12.5	1927	207	0.4	Acceptable	Too Low
44	Runway	150	1612	207	0.5	Acceptable	Too Low
45	Runway	150	912	207	1.2	Acceptable	Perceptible
46	Buildings/Structures	12.5	1070	207	0.9	Acceptable	Perceptible
47	Heli Pad	150	1075	207	0.9	Acceptable	Perceptible
48	C35 Road	150	2265	207	0.3	Acceptable	N/A
49	M76 Road	150	2483	207	0.2	Acceptable	N/A
50	D1930 Road	150	1650	207	0.5	Acceptable	N/A
51	D1930 Road	150	1269	207	0.7	Acceptable	N/A
52	C36 Road	150	1284	207	0.7	Acceptable	N/A
53	D3714 Road	150	1565	207	0.5	Acceptable	N/A
54	Tailings Dam	25	1982	207	0.3	Acceptable	Too Low
55	Buildings/Structures	12.5	1344	207	0.6	Acceptable	Too Low
56	Buildings/Structures	12.5	1362	207	0.6	Acceptable	Too Low
57	Buildings/Structures	12.5	1502	207	0.5	Acceptable	Too Low
58	Industrial Structures (Mine)	25	1164	207	0.8	Acceptable	Perceptible
59	Sub Station	25	1089	207	0.9	Acceptable	Perceptible
60	Buildings/Structures	12.5	1324	207	0.7	Acceptable	Too Low
61	Mine Buildings/Structures	25	847	207	1.4	Acceptable	Perceptible
62	Mine Buildings/Structures	25	460	207	3.8	Acceptable	Perceptible
63	Mine Buildings/Structures	25	461	207	3.8	Acceptable	Perceptible
64	Mine Buildings/Structures	25	223	207	12.4	Acceptable	Unpleasant
65	Communication Tower	25	1061	207	0.9	Acceptable	N/A
66	Power Lines/Pylons - Inside Pit Area	75	-	207	-	-	-
67	Power Lines/Pylons	75	25	207	469.3	Problematic	N/A
68	Power Lines/Pylons	75	83	207	63.1	Acceptable	N/A
69	Power Lines/Pylons	75	123	207	33.1	Acceptable	N/A
70	Power Lines/Pylons	75	105	207	42.9	Acceptable	N/A
71	Power Lines/Pylons	75	87	207	58.3	Acceptable	N/A
72	Power Lines/Pylons	75	78	207	69.9	Acceptable	N/A
73	Power Lines/Pylons	75	72	207	80.5	Problematic	N/A
74	Power Lines/Pylons	75	87	207	58.6	Acceptable	N/A
75	Power Lines/Pylons	75	136	207	28.0	Acceptable	N/A
76	Power Lines/Pylons	75	174	207	18.8	Acceptable	N/A
77	Power Lines/Pylons	75	229	207	11.9	Acceptable	N/A
78	Power Lines/Pylons	75	280	207	8.5	Acceptable	N/A
79	Power Lines/Pylons	75	285	207	8.3	Acceptable	N/A
80	Power Lines/Pylons	75	331	207	6.5	Acceptable	N/A
81	Power Lines/Pylons	75	347	207	6.0	Acceptable	N/A
82	Stormwater Canal	150	339	207	6.2	Acceptable	N/A
83	Stormwater Canal	150	412	207	4.5	Acceptable	N/A
84	Stormwater Canal	150	452	207	3.9	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
85	Stormwater Canal	150	566	207	2.7	Acceptable	N/A
86	Stormwater Canal	150	607	207	2.4	Acceptable	N/A
87	Stormwater Canal	150	667	207	2.0	Acceptable	N/A
88	Stormwater Canal	150	734	207	1.7	Acceptable	N/A
89	Stormwater Canal	150	490	207	3.4	Acceptable	N/A
90	Stormwater Canal	150	431	207	4.2	Acceptable	N/A
91	Stormwater Canal	150	622	207	2.3	Acceptable	N/A
92	Reservoir	50	803	207	1.5	Acceptable	N/A
93	Dams	50	1805	207	0.4	Acceptable	N/A
94	Buildings/Structures (Clinic)	12.5	2002	207	0.3	Acceptable	Too Low
95	Ruins	6	1936	207	0.4	Acceptable	N/A
96	Reservoir	50	2051	207	0.3	Acceptable	N/A
97	Houses	12.5	2093	207	0.3	Acceptable	Too Low
98	Houses	12.5	2137	207	0.3	Acceptable	Too Low
99	Houses	12.5	2183	207	0.3	Acceptable	Too Low
100	Houses	12.5	2195	207	0.3	Acceptable	Too Low
101	Buildings/Structures	12.5	2308	207	0.3	Acceptable	Too Low
102	Houses	12.5	2464	207	0.2	Acceptable	Too Low
103	Houses	12.5	2759	207	0.2	Acceptable	Too Low
104	Houses	12.5	2951	207	0.2	Acceptable	Too Low
105	Houses	12.5	2907	207	0.2	Acceptable	Too Low
106	Houses	12.5	2571	207	0.2	Acceptable	Too Low
107	Houses	12.5	2549	207	0.2	Acceptable	Too Low
108	Houses	12.5	2650	207	0.2	Acceptable	Too Low
109	Houses	12.5	2380	207	0.2	Acceptable	Too Low
110	Houses	12.5	2469	207	0.2	Acceptable	Too Low
111	Houses	12.5	2461	207	0.2	Acceptable	Too Low
112	Houses	12.5	2673	207	0.2	Acceptable	Too Low
113	Houses	12.5	2493	207	0.2	Acceptable	Too Low
114	Houses	12.5	2364	207	0.3	Acceptable	Too Low
115	Houses	12.5	2270	207	0.3	Acceptable	Too Low
116	Houses	12.5	2387	207	0.2	Acceptable	Too Low
117	Houses	12.5	2685	207	0.2	Acceptable	Too Low
118	Houses	12.5	2812	207	0.2	Acceptable	Too Low
119	Buildings/Structures	12.5	2752	207	0.2	Acceptable	Too Low
120	Buildings/Structures	12.5	2797	207	0.2	Acceptable	Too Low
121	Buildings/Structures	12.5	2742	207	0.2	Acceptable	Too Low
122	Houses	12.5	2633	207	0.2	Acceptable	Too Low
123	Buildings/Structures	12.5	2223	207	0.3	Acceptable	Too Low
124	Buildings/Structures	12.5	2528	207	0.2	Acceptable	Too Low
125	Graveyard	50	4226	207	0.1	Acceptable	N/A
126	School	25	1995	207	0.3	Acceptable	Too Low
127	Reservoir	50	1407	207	0.6	Acceptable	N/A
128	Old Sub Station	25	450	207	3.9	Acceptable	N/A
129	Old Abandoned Mine Structures	25	882	207	1.3	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
130	Old Abandoned Mine Structures	25	287	207	8.2	Acceptable	N/A
131	Fibre Optical Cable	50	186	207	16.7	Acceptable	N/A
132	Primary Crusher	200	269	207	9.1	Acceptable	N/A

15.2 Summary of ground vibration levels

The opencast operations were evaluated for expected levels of ground vibration from future blasting operations. Review of the site and the surrounding installations / houses / buildings showed that structures vary in distances from the pit area. The influences will also vary with distance from the pit area. The model used for evaluation does indicate significant levels. It will be imperative to ensure that a monitoring program is done to confirm levels of ground vibration to ensure that ground vibration levels are not exceeded.

The evaluation mainly considered a distance up to 3500 m from the pit area. The closest structures observed are the Power Lines, Boreholes, Fibre Optical Cable and Mine Buildings/Structures. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage. The ground vibration levels predicted for these POI's ranged between 0.1 mm/s and 469.3 mm/s for structures surrounding the open pit area.

The distances between structures and the pit area are a contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated those levels of ground vibration will change as well. In view of the minimum and maximum charge specific attention will need to be given to specific areas. The maximum charge indicated four POI's of concern in relation to possible structural damage.

The nearest public houses are located 1070 m from the Pit boundary. Ground vibration level predicted at this building where people may be present is 0.9 mm/s for the maximum charge. In view of this no specific mitigations will be required.

Structure conditions ranged from industrial construction to poor condition structures.

On a human perception scale three POI's were identified where vibration levels may be perceptible and lower for the minimum charge and nine POI's for the maximum charge. One POI was identified where vibration levels may be unpleasant for the maximum charge. Four POI's might be of concern to structural damage on maximum charge. Perceptible levels of vibration may be experienced up to 1000 m, unpleasant up to 300m and intolerable up to 150 m. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 145 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have lesser influence on these points.

Mitigation of ground vibration was considered and discussed in Section 18.4. A detail inspection of the area and accurate identification of structures will also need to be done to ensure the levels of ground vibration allowable and limit to be applied.

15.3 Ground Vibration and human perception

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to an average of 30Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 18 below). The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. Based on the maximum charge and ground vibration predicted over distance it can be seen from Figure 18 that up to a distance of 3485 m people may experience levels of ground vibration as perceptible. At 1225 m and closer the perception of ground vibration could be unpleasant. Closer than 620 m the levels will be intolerable and generally greater than limits applied for structures in the areas.

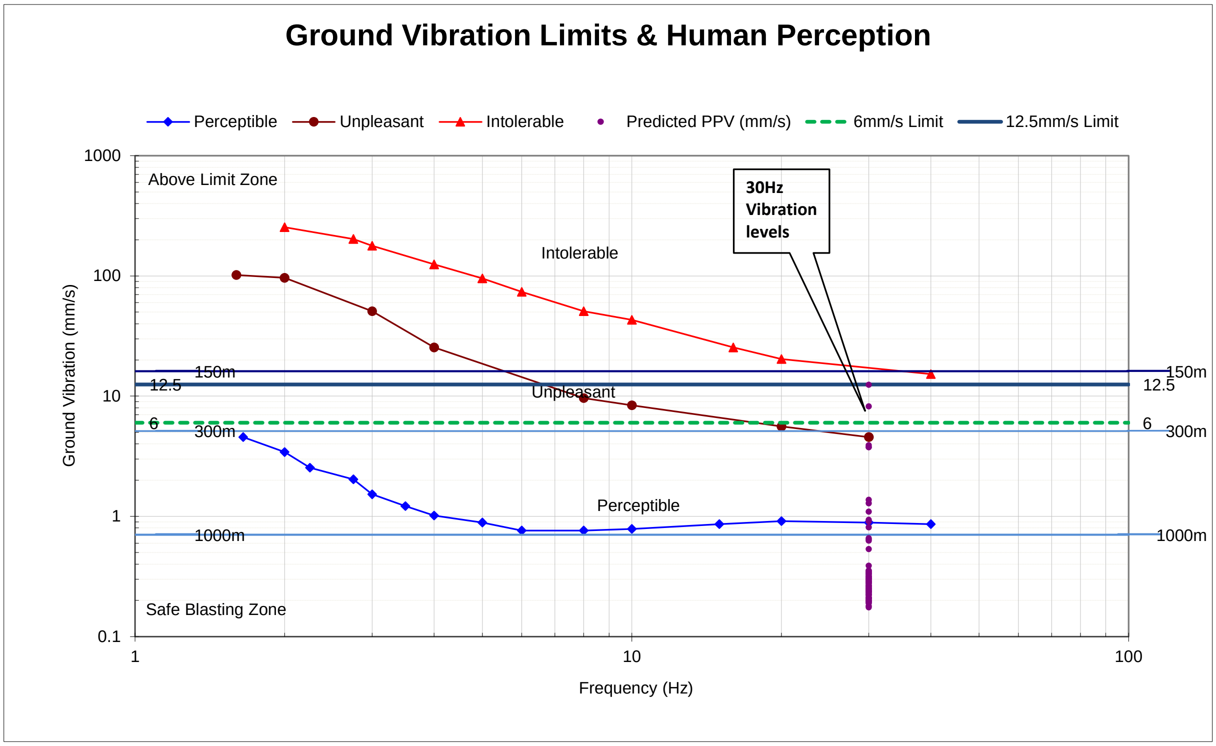


Figure 18: The effect of ground vibration with human perception and vibration limits

15.4 Vibration impact on roads

The C35, C36, D1930, D3714 and M76 roads, is at an approximate distance of 2265 m (C35), 1284 m (C36), 1269 m (D1930), 1565 m (D3714) and 2483 m (M76). No specific consideration regarding effects from blasting operations will be required for these roads.

15.5 Potential that vibration will upset adjacent communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. The nearest houses (POI 46) are approximately 1070 m from the planned operation. These buildings are located such that levels of ground vibration predicted are acceptable for structures but may be perceptible on a human perception level.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 1000 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 699 m. Within these distance ranges there are no houses. The anticipated ground vibration levels are certain to have possibility of upsetting the house holds within these ranges. Intolerable levels are expected up to a distance of 150 m.

The importance of good public relations cannot be over emphasised. People tend to react negatively on experiencing of effects from blasting such as ground vibration and air blast. Even at low levels when damage to structures is out of the question it may upset people. Proper and appropriate communication with neighbours about blasting, monitoring and actions done for proper control will be required.

15.6 Cracking of houses and consequent devaluation

The structures found in the areas of concern ranges from informal building style to brick and mortar structures. There are various buildings found within the 3500 m range from the mining area. Building style and materials will certainly contribute to additional cracking apart from influences such as blasting operations.

The presence of general vertical cracks, horizontal and diagonal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. Mining operations may not have influence to change the status quo of any property if correct precautions are considered.

The proposed limits as applied in this document i.e. 6 mm/s, 12.5 mm/s and 25 mm/s are considered sufficient to ensure that additional damage is not introduced to the different categories of structures. It is expected that, should levels of ground vibration be maintained within these limits, the possibility of inducing damage is limited.

15.7 Review of expected air blast

Presented herewith are the expected air blast level contours and discussion of relevant influences. Expected air blast levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns. Tables are provided for each of the different charge models done with regards to:

- "Tag" No. is number corresponding to the location indicated on POI figures;
- "Description" indicates the type of the structure;
- "Distance" is the distance between the structure and edge of the pit area;
- "Air Blast (dB)" is the calculated air blast level at the structure;
- "Possible concern" indicates if there is any concern for structural damage or human perception. Indicators used are:
  - "Problematic" where there is real concern for possible damage – at levels greater than 134 dB;
  - "Complaint" where people will be complaining due to the experienced effect on structures at levels of 120 dB and higher (not necessarily damaging);
  - "Acceptable" if levels are less than 120 dB;
  - "Low" where there is very limited possibility that the levels will give rise to any influence on people or structures. Levels below 115 dB could be considered to have low or negligible possibility of influence.

Presented are simulations for expected air blast levels from two different charge masses at each pit area. Colour codes used in tables are as follows:

Air blast levels higher than proposed limit is coloured "Red"
Air blast levels indicated as possible Complaint is coloured "Mustard"
POI's that are found inside the pit area is coloured "Olive Green"

15.7.1 Air blast minimum charge mass per delay – 69 kg

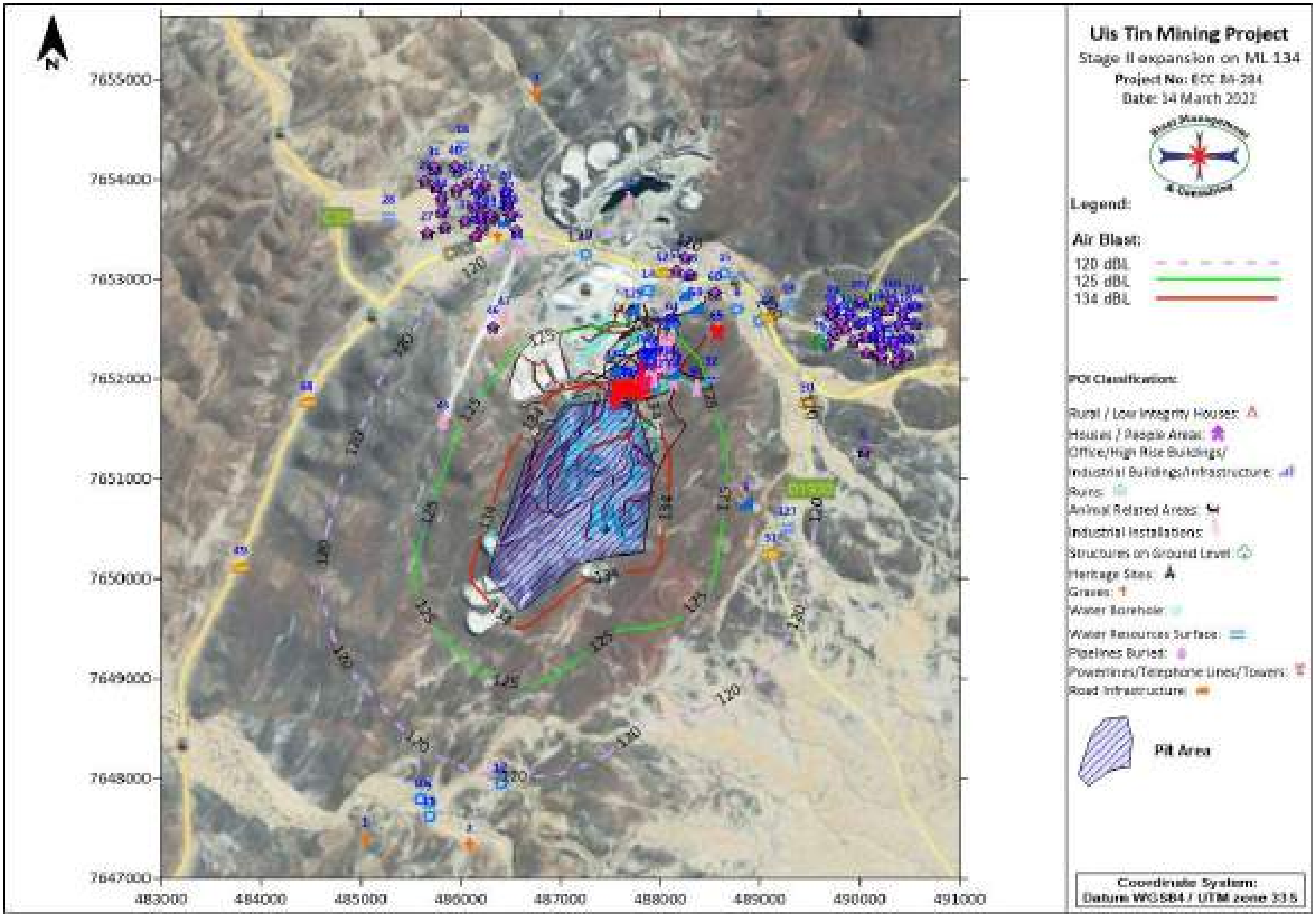


Figure 19: Air blast influence from minimum charge

Table 11: Air blast evaluation for minimum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Grave (1) - Site 312/847	2761	116.9	N/A
2	Graves (22) - Site 312/849	2397	117.8	N/A
3	Graves (100) - Site 312/893	3138	116.1	N/A
4	Graves (26) - Site 312/901	1830	119.5	N/A
5	Mine village - Site 312/900	2117	118.5	N/A
6	Mine adit - Site 312/899	972	123.3	N/A
7	Borehole (BH1)	1470	120.8	N/A
8	Borehole (BH2)	1367	121.2	N/A
9	Borehole (BH3)	2130	118.5	N/A
10	Borehole (BH4)	2141	118.5	N/A
11	Borehole (BH5)	2260	118.1	N/A
12	Borehole (BH6)	1747	119.7	N/A
13	Borehole (BH8) - Inside Pit Area	-	-	-
14	Borehole (BH9)	1092	122.6	N/A
15	Borehole (BH10)	1543	120.5	N/A
16	Borehole (BH11)	74	139.2	N/A
17	Borehole (BH12)	1486	120.7	N/A
18	Reservoir	2809	116.8	N/A
19	Buildings/Structures (Uis Elephant Guesthouse)	2311	118.0	Acceptable
20	Guesthouse/Lodge	2235	118.2	Acceptable
21	Church	2065	118.7	Acceptable
22	Houses	2120	118.5	Acceptable
23	Filling Station	1957	119.0	Acceptable
24	Buildings/Structures (Brandberg Rest Camp)	2022	118.8	Acceptable
25	Shopping Centre	1969	119.0	Acceptable
26	Public (Riemvasmaak Community Conservancy)	1822	119.5	Acceptable
27	Buildings/Structures	2220	118.2	Acceptable
28	Reservoir	2597	117.3	N/A
29	Building/Structure	2654	117.2	Acceptable
30	Public (Campsite and B&B)	2546	117.4	Acceptable
31	Buildings/Structures	2725	117.0	Acceptable
32	Houses	2163	118.4	Acceptable
33	Houses	2304	118.0	Acceptable
34	Houses	2417	117.7	Acceptable
35	Houses	2427	117.7	Acceptable
36	Houses	2185	118.3	Acceptable
37	Houses	2112	118.5	Acceptable
38	Shopping Centre	2069	118.7	Acceptable
39	Swimming Pool	2057	118.7	N/A
40	Buildings/Structures	2643	117.2	Acceptable
41	Houses	2444	117.7	Acceptable
42	Houses	2358	117.9	Acceptable
43	Structure	1927	119.1	Acceptable
44	Runway	1612	120.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
45	Runway	912	123.7	N/A
46	Buildings/Structures	1070	122.7	Complaint
47	Heli Pad	1075	122.7	N/A
48	C35 Road	2265	118.1	N/A
49	M76 Road	2483	117.6	N/A
50	D1930 Road	1650	120.1	N/A
51	D1930 Road	1269	121.7	N/A
52	C36 Road	1284	121.6	N/A
53	D3714 Road	1565	120.4	N/A
54	Tailings Dam	1982	118.9	N/A
55	Buildings/Structures	1344	121.4	Complaint
56	Buildings/Structures	1362	121.2	Complaint
57	Buildings/Structures	1502	120.7	Complaint
58	Industrial Structures (Mine)	1164	122.2	Complaint
59	Sub Station	1089	122.6	N/A
60	Buildings/Structures	1324	121.4	Complaint
61	Mine Buildings/Structures	847	124.2	Complaint
62	Mine Buildings/Structures	460	127.9	Complaint
63	Mine Buildings/Structures	461	127.9	Complaint
64	Mine Buildings/Structures	223	132.4	Complaint
65	Communication Tower	1061	122.8	N/A
66	Power Lines/Pylons - Inside Pit Area	-	-	-
67	Power Lines/Pylons	25	146.0	N/A
68	Power Lines/Pylons	83	138.5	N/A
69	Power Lines/Pylons	123	136.1	N/A
70	Power Lines/Pylons	105	137.0	N/A
71	Power Lines/Pylons	87	138.2	N/A
72	Power Lines/Pylons	78	138.9	N/A
73	Power Lines/Pylons	72	139.4	N/A
74	Power Lines/Pylons	87	138.2	N/A
75	Power Lines/Pylons	136	135.4	N/A
76	Power Lines/Pylons	174	133.9	N/A
77	Power Lines/Pylons	229	132.2	N/A
78	Power Lines/Pylons	280	131.0	N/A
79	Power Lines/Pylons	285	130.9	N/A
80	Power Lines/Pylons	331	130.0	N/A
81	Power Lines/Pylons	347	129.7	N/A
82	Stormwater Canal	339	129.8	N/A
83	Stormwater Canal	412	128.6	N/A
84	Stormwater Canal	452	128.0	N/A
85	Stormwater Canal	566	126.7	N/A
86	Stormwater Canal	607	126.2	N/A
87	Stormwater Canal	667	125.6	N/A
88	Stormwater Canal	734	125.1	N/A
89	Stormwater Canal	490	127.6	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
90	Stormwater Canal	431	128.3	N/A
91	Stormwater Canal	622	126.1	N/A
92	Reservoir	803	124.5	N/A
93	Dams	1805	119.5	N/A
94	Buildings/Structures (Clinic)	2002	118.9	Acceptable
95	Ruins	1936	119.1	N/A
96	Reservoir	2051	118.7	N/A
97	Houses	2093	118.6	Acceptable
98	Houses	2137	118.5	Acceptable
99	Houses	2183	118.3	Acceptable
100	Houses	2195	118.3	Acceptable
101	Buildings/Structures	2308	118.0	Acceptable
102	Houses	2464	117.6	Acceptable
103	Houses	2759	116.9	Acceptable
104	Houses	2951	116.5	Acceptable
105	Houses	2907	116.6	Acceptable
106	Houses	2571	117.3	Acceptable
107	Houses	2549	117.4	Acceptable
108	Houses	2650	117.2	Acceptable
109	Houses	2380	117.8	Acceptable
110	Houses	2469	117.6	Acceptable
111	Houses	2461	117.6	Acceptable
112	Houses	2673	117.1	Acceptable
113	Houses	2493	117.5	Acceptable
114	Houses	2364	117.8	Acceptable
115	Houses	2270	118.1	Acceptable
116	Houses	2387	117.8	Acceptable
117	Houses	2685	117.1	Acceptable
118	Houses	2812	116.8	Acceptable
119	Buildings/Structures	2752	116.9	Acceptable
120	Buildings/Structures	2797	116.9	Acceptable
121	Buildings/Structures	2742	117.0	Acceptable
122	Houses	2633	117.2	Acceptable
123	Buildings/Structures	2223	118.2	Acceptable
124	Buildings/Structures	2528	117.5	Acceptable
125	Graveyard	4226	114.3	N/A
126	School	1995	118.9	Acceptable
127	Reservoir	1407	121.0	N/A
128	Old Sub Station	450	128.1	N/A
129	Old Abandoned Mine Structures	882	123.9	N/A
130	Old Abandoned Mine Structures	287	130.9	N/A
131	Fibre Optical Cable	186	133.5	N/A
132	Primary Crusher	269	131.2	N/A

15.7.2 Air blast maximum charge mass per delay – 207 kg

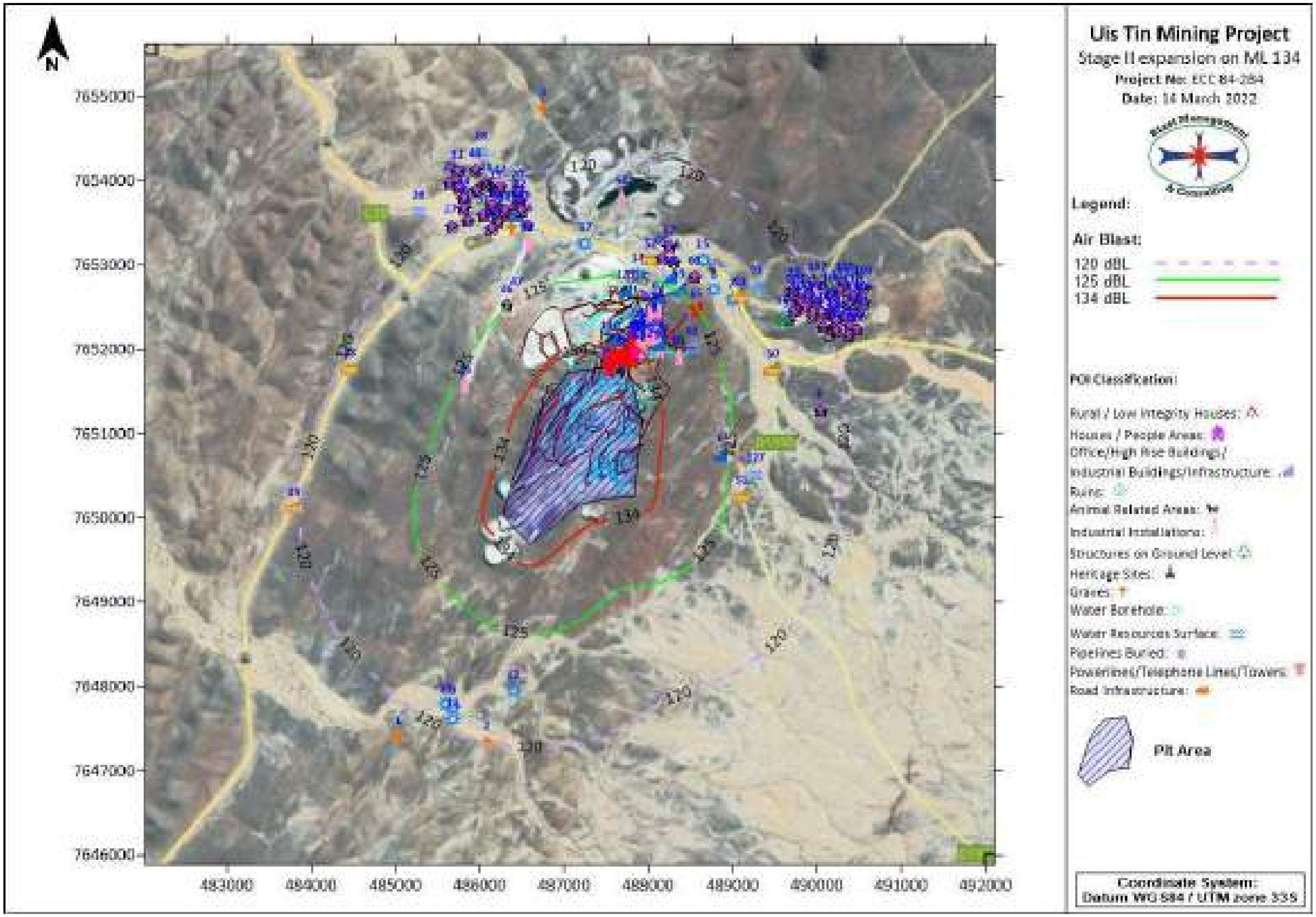


Figure 20: Air blast influence from maximum charge

Table 12: Air blast influence from maximum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Grave (1) - Site 312/847	2761	119.2	N/A
2	Graves (22) - Site 312/849	2397	120.0	N/A
3	Graves (100) - Site 312/893	3138	118.4	N/A
4	Graves (26) - Site 312/901	1830	121.7	N/A
5	Mine village - Site 312/900	2117	120.8	N/A
6	Mine adit - Site 312/899	972	125.6	N/A
7	Borehole (BH1)	1470	123.0	N/A
8	Borehole (BH2)	1367	123.5	N/A
9	Borehole (BH3)	2130	120.7	N/A
10	Borehole (BH4)	2141	120.7	N/A
11	Borehole (BH5)	2260	120.4	N/A
12	Borehole (BH6)	1747	122.0	N/A
13	Borehole (BH8) - Inside Pit Area	-	-	-
14	Borehole (BH9)	1092	124.9	N/A
15	Borehole (BH10)	1543	122.7	N/A
16	Borehole (BH11)	74	141.4	N/A
17	Borehole (BH12)	1486	123.0	N/A
18	Reservoir	2809	119.0	N/A
19	Buildings/Structures (Uis Elephant Guesthouse)	2311	120.2	Complaint
20	Guesthouse/Lodge	2235	120.5	Complaint
21	Church	2065	120.9	Complaint
22	Houses	2120	120.8	Complaint
23	Filling Station	1957	121.3	Complaint
24	Buildings/Structures (Brandberg Rest Camp)	2022	121.1	Complaint
25	Shopping Centre	1969	121.2	Complaint
26	Public (Riemvasmaak Community Conservancy)	1822	121.7	Complaint
27	Buildings/Structures	2220	120.5	Complaint
28	Reservoir	2597	119.6	N/A
29	Building/Structure	2654	119.4	Acceptable
30	Public (Campsite and B&B)	2546	119.6	Acceptable
31	Buildings/Structures	2725	119.2	Acceptable
32	Houses	2163	120.7	Complaint
33	Houses	2304	120.3	Complaint
34	Houses	2417	120.0	Acceptable
35	Houses	2427	120.0	Acceptable
36	Houses	2185	120.6	Complaint
37	Houses	2112	120.8	Complaint
38	Shopping Centre	2069	120.9	Complaint
39	Swimming Pool	2057	121.0	N/A
40	Buildings/Structures	2643	119.4	Acceptable
41	Houses	2444	119.9	Acceptable
42	Houses	2358	120.1	Complaint
43	Structure	1927	121.4	Complaint
44	Runway	1612	122.5	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
45	Runway	912	126.0	N/A
46	Buildings/Structures	1070	125.0	Complaint
47	Heli Pad	1075	125.0	N/A
48	C35 Road	2265	120.4	N/A
49	M76 Road	2483	119.8	N/A
50	D1930 Road	1650	122.3	N/A
51	D1930 Road	1269	124.0	N/A
52	C36 Road	1284	123.9	N/A
53	D3714 Road	1565	122.7	N/A
54	Tailings Dam	1982	121.2	N/A
55	Buildings/Structures	1344	123.6	Complaint
56	Buildings/Structures	1362	123.5	Complaint
57	Buildings/Structures	1502	122.9	Complaint
58	Industrial Structures (Mine)	1164	124.5	Complaint
59	Sub Station	1089	124.9	N/A
60	Buildings/Structures	1324	123.7	Complaint
61	Mine Buildings/Structures	847	126.4	Complaint
62	Mine Buildings/Structures	460	130.2	Complaint
63	Mine Buildings/Structures	461	130.2	Complaint
64	Mine Buildings/Structures	223	134.7	Problematic
65	Communication Tower	1061	125.1	N/A
66	Power Lines/Pylons - Inside Pit Area	-	-	-
67	Power Lines/Pylons	25	148.2	N/A
68	Power Lines/Pylons	83	140.7	N/A
69	Power Lines/Pylons	123	138.3	N/A
70	Power Lines/Pylons	105	139.3	N/A
71	Power Lines/Pylons	87	140.4	N/A
72	Power Lines/Pylons	78	141.1	N/A
73	Power Lines/Pylons	72	141.6	N/A
74	Power Lines/Pylons	87	140.5	N/A
75	Power Lines/Pylons	136	137.7	N/A
76	Power Lines/Pylons	174	136.2	N/A
77	Power Lines/Pylons	229	134.5	N/A
78	Power Lines/Pylons	280	133.2	N/A
79	Power Lines/Pylons	285	133.1	N/A
80	Power Lines/Pylons	331	132.2	N/A
81	Power Lines/Pylons	347	131.9	N/A
82	Stormwater Canal	339	132.1	N/A
83	Stormwater Canal	412	130.9	N/A
84	Stormwater Canal	452	130.3	N/A
85	Stormwater Canal	566	128.9	N/A
86	Stormwater Canal	607	128.5	N/A
87	Stormwater Canal	667	127.9	N/A
88	Stormwater Canal	734	127.3	N/A
89	Stormwater Canal	490	129.8	N/A
90	Stormwater Canal	431	130.6	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
91	Stormwater Canal	622	128.3	N/A
92	Reservoir	803	126.8	N/A
93	Dams	1805	121.8	N/A
94	Buildings/Structures (Clinic)	2002	121.1	Complaint
95	Ruins	1936	121.4	N/A
96	Reservoir	2051	121.0	N/A
97	Houses	2093	120.9	Complaint
98	Houses	2137	120.7	Complaint
99	Houses	2183	120.6	Complaint
100	Houses	2195	120.6	Complaint
101	Buildings/Structures	2308	120.2	Complaint
102	Houses	2464	119.9	Acceptable
103	Houses	2759	119.2	Acceptable
104	Houses	2951	118.7	Acceptable
105	Houses	2907	118.8	Acceptable
106	Houses	2571	119.6	Acceptable
107	Houses	2549	119.6	Acceptable
108	Houses	2650	119.4	Acceptable
109	Houses	2380	120.1	Complaint
110	Houses	2469	119.9	Acceptable
111	Houses	2461	119.9	Acceptable
112	Houses	2673	119.4	Acceptable
113	Houses	2493	119.8	Acceptable
114	Houses	2364	120.1	Complaint
115	Houses	2270	120.4	Complaint
116	Houses	2387	120.0	Acceptable
117	Houses	2685	119.3	Acceptable
118	Houses	2812	119.0	Acceptable
119	Buildings/Structures	2752	119.2	Acceptable
120	Buildings/Structures	2797	119.1	Acceptable
121	Buildings/Structures	2742	119.2	Acceptable
122	Houses	2633	119.5	Acceptable
123	Buildings/Structures	2223	120.5	Complaint
124	Buildings/Structures	2528	119.7	Acceptable
125	Graveyard	4226	116.5	N/A
126	School	1995	121.2	Complaint
127	Reservoir	1407	123.3	N/A
128	Old Sub Station	450	130.3	N/A
129	Old Abandoned Mine Structures	882	126.2	N/A
130	Old Abandoned Mine Structures	287	133.1	N/A
131	Fibre Optical Cable	186	135.8	N/A
132	Primary Crusher	269	133.5	N/A

15.8 Summary of findings for air blast

Review of the air blast levels indicate more concerns. Air blast predicted for the maximum charge ranges between 116.5 and 134.7 dB for all the POI's considered. This includes the nearest points such as the Mine Buildings/Structures.

The general accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 223 m and closer to pit boundary. Infrastructure at the pit areas such as roads, power lines/pylons are present, but air blast does not have any influence on these installations.

The nearest private structures are located 1324 m from pit edge. Air blast levels from maximum charge is expected to be within the accepted limit but slightly greater than 120 dB. This may contribute to some complaints. All other private structures are further away and levels decrease over distance. Levels are expected to be less than 120 dB at distance of 2387 m from the pit edge.

The possible negative effects from air blast are expected to be the same than that of ground vibration. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pit is located such that "free blasting" – meaning no controls on blast preparation – will not be possible. The effect of stemming control will need to be considered. In many cases the lack of proper control on stemming material and length contributes mostly to complaints from neighbours.

15.9 Fly-rock unsafe zone

The occurrence of fly rock in any form will have a negative impact if found to travel outside the unsafe zone. This unsafe zone may be anything between 10 m or 1000 m. A general unsafe zone applied by most mines is normally considered to be within a radius of 500 m from the blast; but needs to be qualified and determined as best possible.

Calculations are also used to help and assist determining safe distances. A safe distance from blasting is calculated following rules and guidelines from the International Society of Explosives Engineers (ISEE) Blasters Handbook. Using this calculation, the minimum safe distances can be determined that should be cleared of people, animals and equipment. Figure 21 shows the results from the ISEE calculations for fly rock range based on an 89 mm diameter blast hole and 1.5 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 388 m. The absolute minimum unsafe zone is then the 388 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated. Figure 22 shows the area around the Pit area that incorporates the 388 m unsafe zone.

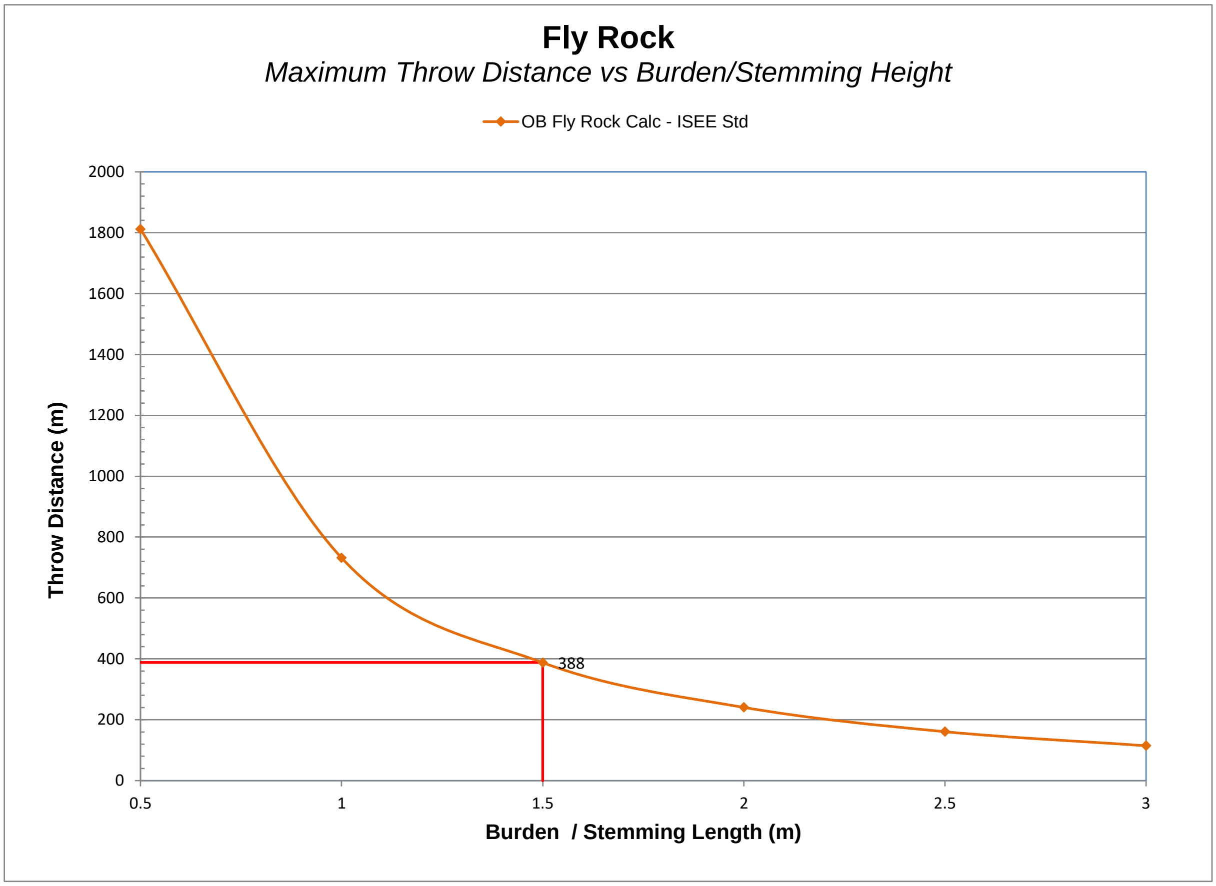


Figure 21: Fly rock prediction calculation

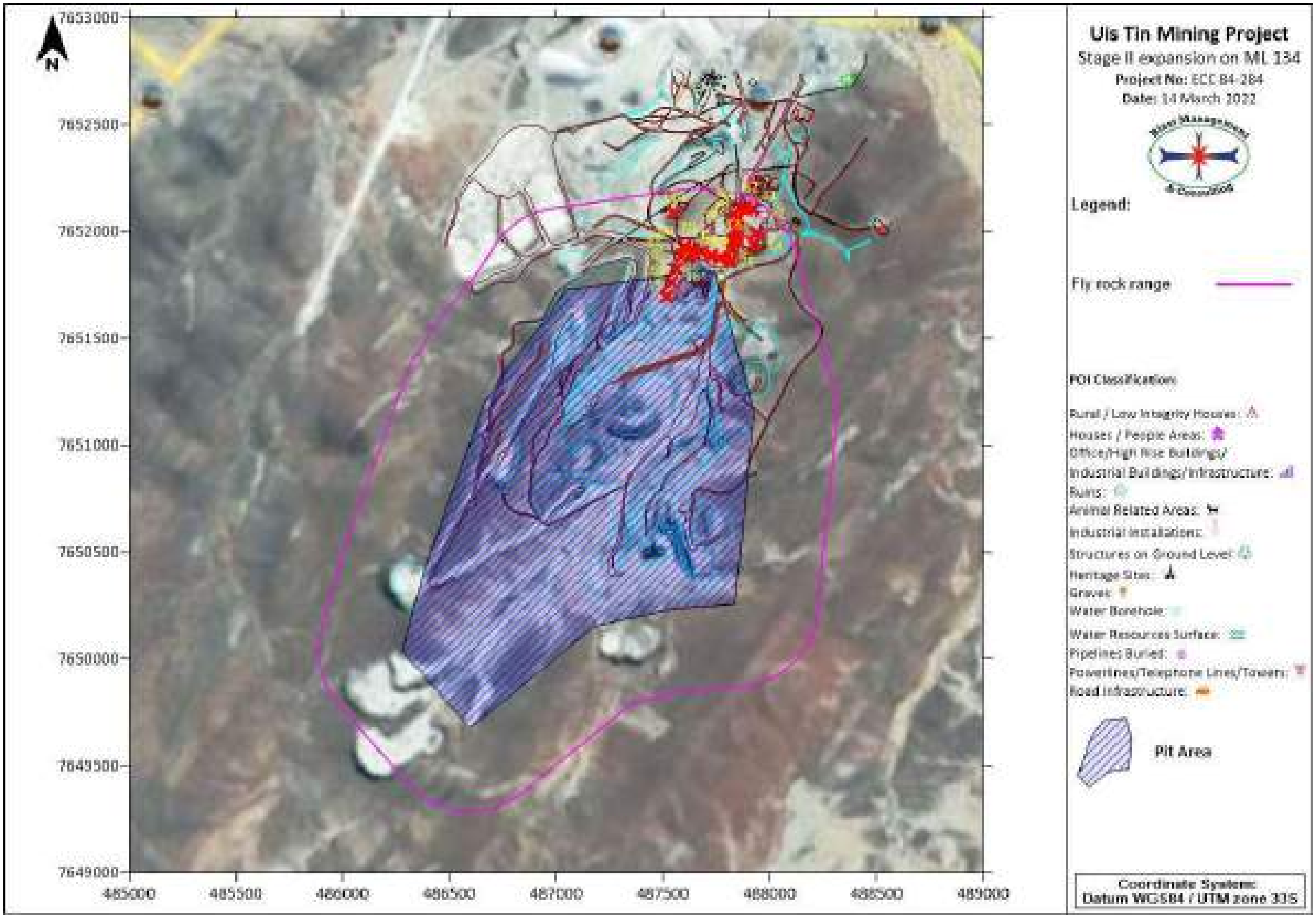


Figure 22: Predicted Fly Rock Exclusion Zone for the Pit area

Review of the calculated unsafe zone showed twenty-three POI's (included are two POI's that falls within the Pit Area) are within the unsafe zone. There are no private houses / structures within the range of the calculated unsafe zone. Table 13 below shows the POI's of concern and coordinates.

Table 13: Fly rock concern POI's

Tag	Description	Y	X
13	Borehole (BH8) - Inside Pit Area	487520.26	7651695.29
16	Borehole (BH11)	487625.96	7651883.51
64	Mine Buildings/Structures	487923.27	7651940.61
66	Power Lines/Pylons - Inside Pit Area	487542.63	7651761.39
67	Power Lines/Pylons	487564.50	7651824.76
68	Power Lines/Pylons	487586.39	7651887.09
69	Power Lines/Pylons	487600.88	7651929.21
70	Power Lines/Pylons	487638.52	7651916.64
71	Power Lines/Pylons	487680.28	7651903.04
72	Power Lines/Pylons	487724.69	7651888.20
73	Power Lines/Pylons	487765.92	7651873.84
74	Power Lines/Pylons	487815.39	7651857.83
75	Power Lines/Pylons	487825.12	7651915.85
76	Power Lines/Pylons	487832.86	7651955.23
77	Power Lines/Pylons	487845.02	7652011.67
78	Power Lines/Pylons	487855.36	7652063.02
79	Power Lines/Pylons	487832.24	7652076.86
80	Power Lines/Pylons	487865.32	7652114.09
81	Power Lines/Pylons	487919.46	7652105.13
82	Stormwater Canal	487887.43	7652112.82
130	Old Abandoned Mine Structures	487551.21	7652087.32
131	Fibre Optical Cable	487850.63	7651959.03
132	Primary Crusher	487940.90	7651990.57

15.10 Noxious fumes

The occurrence of fumes in the form the NOx gas is not a given and very dependent on various factors as discussed in Section 13.6. However, the occurrence of fumes should be closely monitored. Furthermore, nothing can be stated as to fume dispersal to nearby farmsteads, but if anybody is present in the path of the fume cloud it could be problematic.

15.11 Water borehole influence

Location of boreholes for water was evaluated for possible influence from blasting. Hydrocencus and Monitoring boreholes were identified within the influence area at the Pit area. There are boreholes that are in proximity of the blasting areas and could be problematic. Table 14 shows all the identified boreholes. Figure 23 shows the location of the boreholes in the area. The importance of these problematic boreholes must be defined by the client and if needed alternative boreholes provided.

Table 14: Identified water boreholes

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m) to Pit	Predicted PPV (mm/s)
7	Borehole (BH1)	488994.16	7652581.75	50	1470	0.6
8	Borehole (BH2)	488777.20	7652703.34	50	1367	0.6
9	Borehole (BH3)	485683.96	7647753.71	50	2130	0.3
10	Borehole (BH4)	485593.68	7647786.83	50	2141	0.3
11	Borehole (BH5)	485687.20	7647609.83	50	2260	0.3
12	Borehole (BH6)	486400.64	7647942.47	50	1747	0.4
13	Borehole (BH8) - Inside Pit Area	487520.26	7651695.29	50	-	-
14	Borehole (BH9)	487881.52	7652890.86	50	1092	0.9
15	Borehole (BH10)	488647.24	7653057.42	50	1543	0.5
16	Borehole (BH11)	487625.96	7651883.51	50	74	76.0
17	Borehole (BH12)	487250.30	7653255.61	50	1486	0.5

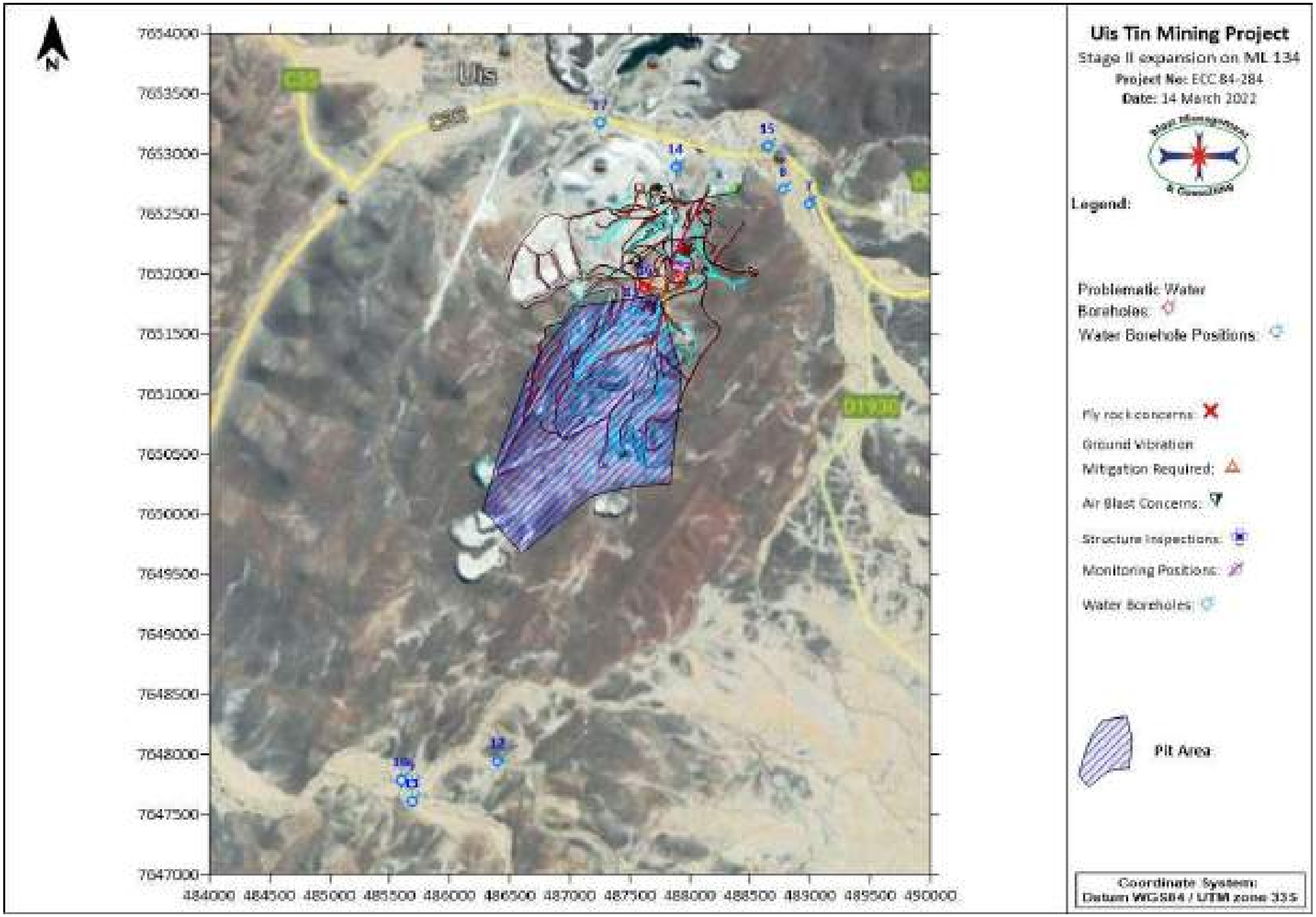


Figure 23: Location of the Boreholes for the Pit area

16 Potential Environmental Impact Assessment: Operational Phase

The following is the impact assessment of the various concerns covered by this report. The impact assessment and evaluation below were used for analysis and evaluation of aspects discussed in this report. The outcome of the analysis is provided in Table 19 with before mitigation and after mitigation. This risk assessment is a one-sided analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation.

16.1 Assessment Criteria

The criteria for the description and assessment of environmental impacts were drawn from the EIA Guidelines (DEAT, Environmental Impact Assessment Guidelines., 1998) and as amended from time to time (DEAT, Impact Significance, Integrated Environmental Management, Information series 5., 2002).

The level of detail as depicted in the EIA Guidelines (DEAT, Environmental Impact Assessment Guidelines., 1998) (DEAT, Impact Significance, Integrated Environmental Management, Information series 5., 2002)) was fine-tuned by assigning specific values to each impact. In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes, each aspect was assigned a value, ranging from one (1) to five (5), depending on its definition. This assessment is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. An explanation of the impact assessment criteria is defined below.

Table 15: Impact Assessment Criteria

EXTENT	
Classification of the physical and spatial scale of the impact	
Footprint	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.
Site	The impact could affect the whole, or a significant portion of the site.
Regional	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns.
National	The impact could have an effect that expands throughout the country (South Africa).
International	Where the impact has international ramifications that extend beyond the boundaries of South Africa.
DURATION	
The lifetime of the impact that is measured in relation to the lifetime of the proposed development.	
Short term	The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase.
Short to Medium term	The impact will be relevant through to the end of a construction phase (1.5 years).

EXTENT	
Classification of the physical and spatial scale of the impact	
Medium term	The impact will last up to the end of the development phases, where after it will be entirely negated.
Long term	The impact will continue or last for the entire operational lifetime i.e. exceed 30 years of the development, but will be mitigated by direct human action or by natural processes thereafter.
Permanent	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.
INTENSITY	
The intensity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functioning, or slightly alters the environment itself. The intensity is rated as	
Low	The impact alters the affected environment in such a way that the natural processes or functions are not affected.
Medium	The affected environment is altered, but functions and processes continue, albeit in a modified way.
High	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.
PROBABILITY	
This describes the likelihood of the impacts actually occurring. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows:	
Improbable	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0 %).
Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined as 25 %.
Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined as 50 %.
Highly Likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75 %.
Definite	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100 %.

The status of the impacts and degree of confidence with respect to the assessment of the significance must be stated as follows:

- **Status of the impact:** A description as to whether the impact would be positive (a benefit), negative (a cost), or neutral.
- **Degree of confidence in predictions:** The degree of confidence in the predictions, based on the availability of information and specialist knowledge.

Other aspects to take into consideration in the specialist studies are:

- Impacts should be described both before and after the proposed mitigation and management measures have been implemented.

- All impacts should be evaluated for the full lifecycle of the proposed development, including construction, operation and decommissioning.
- The impact evaluation should take into consideration the cumulative effects associated with this and other facilities which are either developed or in the process of being developed in the region.
- The specialist studies must attempt to quantify the magnitude of potential impacts (direct and cumulative effects) and outline the rationale used. Where appropriate, national standards are to be used as a measure of the level of impact.

16.2 Mitigation Assessment

The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.

16.2.1 Determination of Significance-Without Mitigation

Significance is determined through a synthesis of impact characteristics as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact “without mitigation” is the prime determinant of the nature and degree of mitigation required. Where the impact is positive, significance is noted as “positive”. Significance is rated on the following scale:

Table 16: Significance Without Mitigation

NO SIGNIFICANCE	The impact is not substantial and does not require any mitigation action.
LOW	The impact is of little importance but may require limited mitigation.
MEDIUM	The impact is of importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impacts to acceptable levels.
HIGH	The impact is of major importance. Failure to mitigate, with the objective of reducing the impact to acceptable levels, could render the entire development option or entire project proposal unacceptable. Mitigation is therefore essential.

16.2.2 Determination of Significance- With Mitigation

Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. Significance with mitigation is rated on the following scale:

Table 17: Significance With Mitigation

NO SIGNIFICANCE	The impact will be mitigated to the point where it is regarded as insubstantial.
LOW	The impact will be mitigated to the point where it is of limited importance.

LOW TO MEDIUM	The impact is of importance, however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels.
MEDIUM	Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw.
MEDIUM TO HIGH	The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels.
HIGH	The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.

16.2.3 Assessment Weighting

Each aspect within an impact description was assigned a series of quantitative criteria. Such criteria are likely to differ during the different stages of the project's life cycle. In order to establish a defined base upon which it becomes feasible to make an informed decision, it was necessary to weigh and rank all the criteria.

16.2.4 Ranking, Weighting and Scaling

For each impact under scrutiny, a scaled weighting factor is attached to each respective impact. The purpose of assigning weights serves to highlight those aspects considered the most critical to the various stakeholders and ensure that each specialist's element of bias is considered. The weighting factor also provides a means whereby the impact assessor can successfully deal with the complexities that exist between the different impacts and associated aspect criteria.

Simply, such a weighting factor is indicative of the importance of the impact in terms of the potential effect that it could have on the surrounding environment. Therefore, the aspects considered to have a relatively high value will score a relatively higher weighting than that which is of lower importance.

Table 18: Description of assessment parameters with its respective weighting

EXTENT		DURATION		INTENSITY		PROBABILITY		WEIGHTING FACTOR (WF)		SIGNIFICANCE RATING (SR)	
Footprint	1	Short term	1	Low	1	Probable	1	Low	1	Low	0-19
Site	2	Short to Medium	2			Possible	2	Low to Medium	2	Low to Medium	20-39
Regional	3	Medium term	3	Medium	3	Likely	3	Medium	3	Medium	40-59
National	4	Long term	4			Highly Likely	4	Medium to High	4	Medium to High	60-79
International	5	Permanent	5	High	5	Definite	5	High	5	High	80-100

MITIGATION EFFICIENCY (ME)		SIGNIFICANCE FOLLOWING MITIGATION (SFM)	
High	0.2	Low	0 - 19
Medium to High	0.4	Low to Medium	20 - 39

Medium	0.6	Medium	40 - 59
Low to Medium	0.8	Medium to High	60 - 79
Low	1.0	High	- 100

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned weightings, resulting in a value for each impact (prior to the implementation of mitigation measures).

Equation 1:

Significance Rating (WOM) = (Extent + Intensity + Duration + Probability) x Weighting Factor

16.2.5 Identifying the Potential Impacts With Mitigation Measures (WM)

In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it was necessary to re-evaluate the impact.

16.2.6 Mitigation Efficiency (ME)

The most effective means of deriving a quantitative value of mitigated impacts is to assign each significance rating value (WOM) a mitigation efficiency (ME) rating (**Error! Reference source not found.**). The allocation of such a rating is a measure of the efficiency and effectiveness, as identified through professional experience and empirical evidence of how effectively the proposed mitigation measures will manage the impact.

Thus, the lower the assigned value the greater the effectiveness of the proposed mitigation measures and subsequently, the lower the impacts with mitigation.

Equation 2:

Significance Rating (WM) = Significance Rating (WOM) x Mitigation Efficiency

or WM = WOM x ME

16.2.7 Significance Following Mitigation (SFM)

The significance of the impact after the mitigation measures are taken into consideration. The efficiency of the mitigation measure determines the significance of the impact. The level of impact is therefore seen in its entirety with all considerations considered.

16.3 Assessment

The assessment done was based on evaluating the points of interested that showed expected levels greater than limits. This is however based on the worst-case scenario where blasting is done at the shortest distance from pit area to the point of interest. In after mitigation consideration was given to the fact that blasting will not be constantly at the short distance and the period of time that the influence may be present is significantly reduced due to that only areas or blocks will be blasted at a time.

Table 19: Potential Impacts Without And With Mitigation Measures Mitigation

No.	Receptor / Resource	Process / Activity	Environmental Impact	Extent	Duration	Intensity	Probability	Weighting Factor	Significance		Mitigation and Management Measures	Mitigation Efficiency	Significance Following Mitigation	
									Value	Rating			Value	Rating
1	Graves	Blasting	Ground Vibration	3	4	1	1	1	9	Low	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, using electronic initiation instead of shock tube systems to obtain single hole firing.	0.2	1.8	Low
2	Mine Buildings/Structures	Blasting	Ground Vibration	3	4	1	2	2	20	Low to Medium		0.2	4	Low
3	Old Abandoned Mine Structures	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
4	Borehole	Blasting	Ground Vibration	3	4	5	5	5	85	High		0.2	17	Low
5	Reservoir	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
6	Old Sub Station	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
7	Buildings/Structures	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
8	Sub Station	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
9	Public (Riemvasmaak Community Conservancy)	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
10	Structure	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
11	Ruins	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
12	Filling Station	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
13	Shopping Centre	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
14	School	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
15	Buildings/Structures (Clinic)	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
16	Buildings/Structures (Brandberg Rest Camp)	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
17	Swimming Pool	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
18	Church	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
19	Runway	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
20	Houses	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low

No.	Receptor / Resource	Process / Activity	Environmental Impact	Extent	Duration	Intensity	Probability	Weighting Factor	Significance		Mitigation and Management Measures	Mitigation Efficiency	Significance Following Mitigation	
									Value	Rating			Value	Rating
21	Heli Pad	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
22	Main Roads	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
23	Tailings Dam	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
24	Communication Tower	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
25	Power Lines/Pylons	Blasting	Ground Vibration	3	4	5	5	5	85	High		0.2	17	Low
26	Guesthouse/Lodge	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
27	Graveyard	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
28	Fibre Optical Cable	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
29	Primary Crusher	Blasting	Ground Vibration	3	4	1	1	1	9	Low		0.2	1.8	Low
31	Mine Buildings/Structures	Blasting	Air Blast	3	4	3	3	3	39	Low to Medium	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, use of specific stemming materials to manage air blast, increased stemming lengths to reduce air blast effect. Used of specific stemming to manage fly rock - crushed aggregate of specific size. Re-design with increased	0.6	23.4	Low to Medium
35	Old Sub Station	Blasting	Air Blast	3	4	1	1	1	9	Low		0.6	5.4	Low
36	Buildings/Structures	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
37	Sub Station	Blasting	Air Blast	3	4	1	1	1	9	Low		0.6	5.4	Low
38	Public (Riemvasmaak Community Conservancy)	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
39	Structure	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
40	Ruins	Blasting	Air Blast	3	4	1	1	1	9	Low		0.6	5.4	Low
41	Filling Station	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
42	Shopping Centre	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
43	School	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
44	Buildings/Structures (Clinic)	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
45	Buildings/Structures (Brandberg Rest Camp)	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium

No.	Receptor / Resource	Process / Activity	Environmental Impact	Extent	Duration	Intensity	Probability	Weighting Factor	Significance		Mitigation and Management Measures	Mitigation Efficiency	Significance Following Mitigation	
									Value	Rating			Value	Rating
47	Church	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium	stemming lengths.	0.6	21.6	Low to Medium
49	Houses	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
53	Communication Tower	Blasting	Air Blast	3	4	3	1	2	22	Low to Medium		0.6	13.2	Low
55	Guesthouse/Lodge	Blasting	Air Blast	3	4	3	2	3	36	Low to Medium		0.6	21.6	Low to Medium
59	Graves	Blasting	Fly Rock	3	4	1	1	1	9	Low	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, use of specific stemming materials to manage air blast, increased stemming lengths to reduce air blast effect. Used of specific stemming to manage fly rock - crushed aggregate of specific size. Re-design with increased stemming lengths.	0.6	5.4	Low
60	Mine Buildings/Structures	Blasting	Fly Rock	3	4	3	4	4	56	Medium		0.6	33.6	Low to Medium
61	Old Abandoned Mine Structures	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
62	Borehole	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
63	Reservoir	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
64	Old Sub Station	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
65	Buildings/Structures	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
66	Sub Station	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
67	Public (Riemvasmaak Community Conservancy)	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
68	Structure	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
69	Ruins	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
70	Filling Station	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
71	Shopping Centre	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
72	School	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
73	Buildings/Structures (Clinic)	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
74	Buildings/Structures (Brandberg Rest Camp)	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
75	Swimming Pool	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
76	Church	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
77	Runway	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
78	Houses	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
79	Heli Pad	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low

No.	Receptor / Resource	Process / Activity	Environmental Impact	Extent	Duration	Intensity	Probability	Weighting Factor	Significance		Mitigation and Management Measures	Mitigation Efficiency	Significance Following Mitigation	
									Value	Rating			Value	Rating
80	Main Roads	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
81	Tailings Dam	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
82	Communication Tower	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
83	Power Lines/Pylons	Blasting	Fly Rock	3	4	5	5	5	85	High		0.6	51	Medium
84	Guesthouse/Lodge	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
85	Graveyard	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
86	Fibre Optical Cable	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low
87	Primary Crusher	Blasting	Fly Rock	3	4	1	1	1	9	Low		0.6	5.4	Low

16.4 Mitigations

In review of the evaluations made in this report it is certain that specific mitigation will be required with regards to ground vibration. Ground vibration is the primary possible cause of structural damage and requires more detailed planning in preventing damage and maintaining levels within accepted norms. Air blast and fly rock can be controlled using proper charging methodology irrespective of the blast hole diameter and patterns used. Ground vibration requires more detailed planning and forms the focus for mitigation measures.

Specific impacts are expected at the following POI's identified. Table 20 shows list of POI's that will need to be considered and Table 21 the POI's that needs specific attention due to location within the pit area. Figure 24 shows the location of these POI's in relation to the pit area.

Table 20: Structures identified as problematic in and around the project area

Tag	Description	Classification	Y	X
16	Borehole (BH11)	10	487625.96	7651883.51
67	Power Lines/Pylons	13	487564.50	7651824.76
73	Power Lines/Pylons	13	487765.92	7651873.84

Table 21: Structures identified inside the planned pit area

Tag	Description	Classification	Y	X
13	Borehole (BH8) - Inside Pit Area	10	487520.26	7651695.29
66	Power Lines/Pylons - Inside Pit Area	13	487542.63	7651761.39

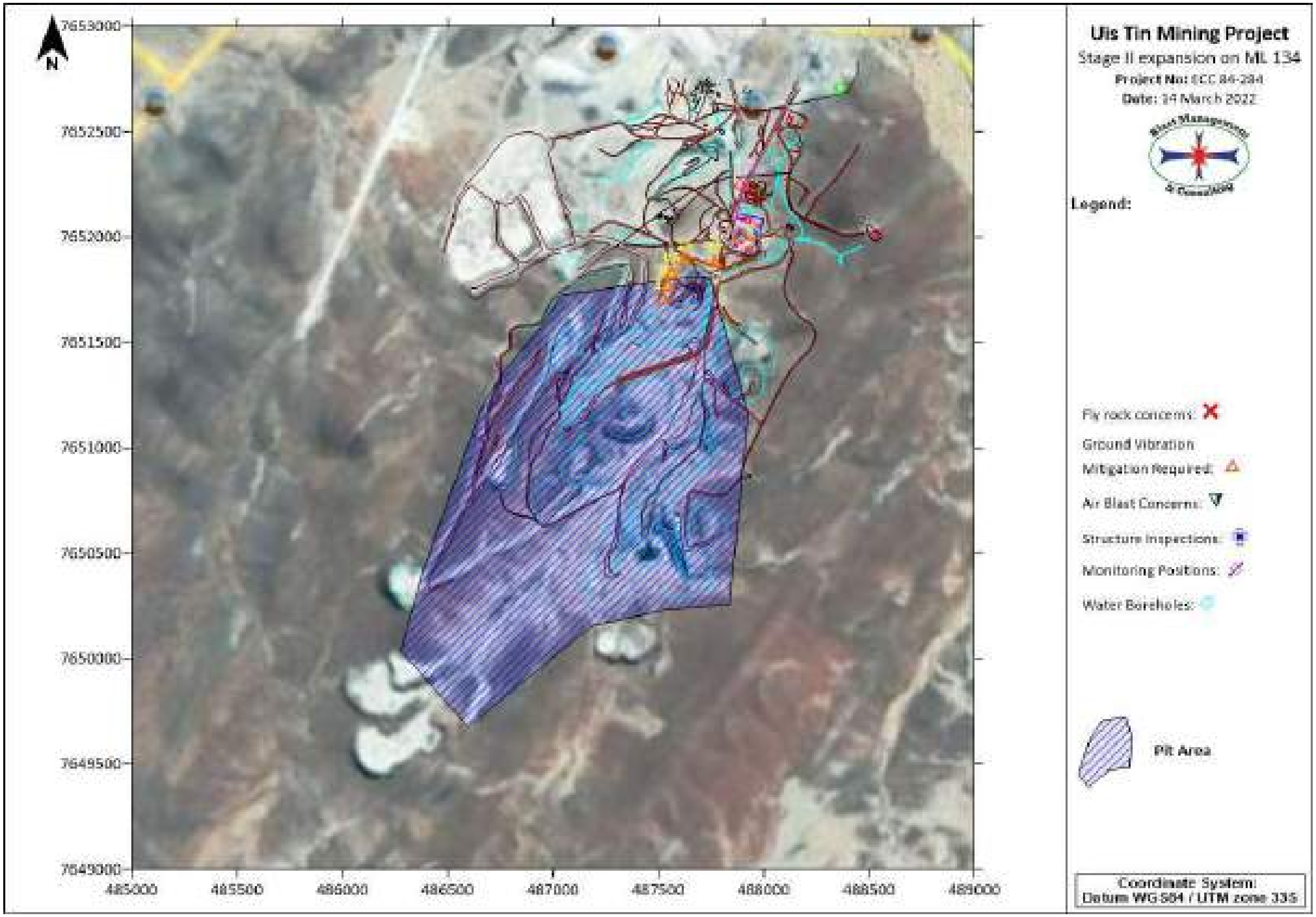


Figure 24: Structures identified where ground vibration mitigation will be required.

Mitigation of ground vibration for this can be done applying the following methods:

- Do blast design that considers the actual blasting, and the ground vibration levels to be adhered too.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.
- Relocate the POI / acquire the POI of concern – mined owned.

The identified POI's of concern is found in close proximity of the actual operations. In order to give indication of the possibilities of mitigation to consider two basic indicators are presented. Firstly, the maximum charge per delay that can be allowed for the shortest distance between blast and POI. Secondly the minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay. These table gives indication for planning of blasts when blasts at shortest distance to the POI's.

Table 22 do show mitigation in the form of maximum charge mass that will be allowed to maintain safe levels of ground vibration. Table 23 shows minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay.

Table 22: Mitigation measures: Maximum charge per delay for distance to POI

Tag	**Description**	**Y**	**X**	**Specific Limit (mm/s)**	**Distance (m)**	**Total Mass/Delay (kg)**	**Predicted PPV (mm/s)**	**Structure Response @ 10Hz**
16	Borehole (BH11)	487625.96	7651883.51	50	74	125	50	Acceptable
67	Power Lines/Pylons	487564.50	7651824.76	75	25	22	75	Acceptable
73	Power Lines/Pylons	487765.92	7651873.84	75	72	190	75	Acceptable

Table 23: Mitigation measures: Minimum distances required

Tag	**Example POI**	**Specific Limit (mm/s)**	**Distance (m)**	**Total Mass/Delay (kg)**
16	Borehole (BH11)	50	96	207
67	Power Lines/Pylons	75	75	207

Based on evaluation done for the planned charge masses mitigation will be required for the Borehole and Power Lines. These POI's vary in distance and it will be required that each be evaluated in relation to a blast to be done. The distance should be checked, the charge mass allowed be calculated and then a design of charging or timing applied to ensure that the limits are not exceed. In most cases basic planned design does not need to change but timing can be adjusted as well electronic timing can used to reduce the charge mass per delay. This must be confirmed with monitoring of ground vibration at the POI.

17 Monitoring

A monitoring programme for recording blasting operations is recommended. The following elements should be part of such a monitoring program:

- Ground vibration and air blast results;
- Blast Information summary;
- Meteorological information at time of the blast;
- Video Recording of the blast;
- Fly rock observations.

Most of the above aspects do not require specific locations of monitoring. Ground vibration and air blast monitoring requires identified locations for monitoring. Monitoring of ground vibration and air blast is done to ensure that the generated levels of ground vibration and air blast comply with recommendations. Proposed positions were selected to indicate the nearest points of interest at which levels of ground vibration and air blast should be within the accepted norms and standards as proposed in this report. The monitoring of ground vibration will also qualify the expected ground vibration and air blast levels and assist in mitigating these aspects properly. This will also contribute to proper relationships with the neighbours.

Three monitoring points were identified as possible locations that will need to be considered. Monitoring positions are indicated in Figure 25 and Table 24 lists the positions with coordinates. These points will need to be re-defined after the first blasts done and the monitoring programme defined.

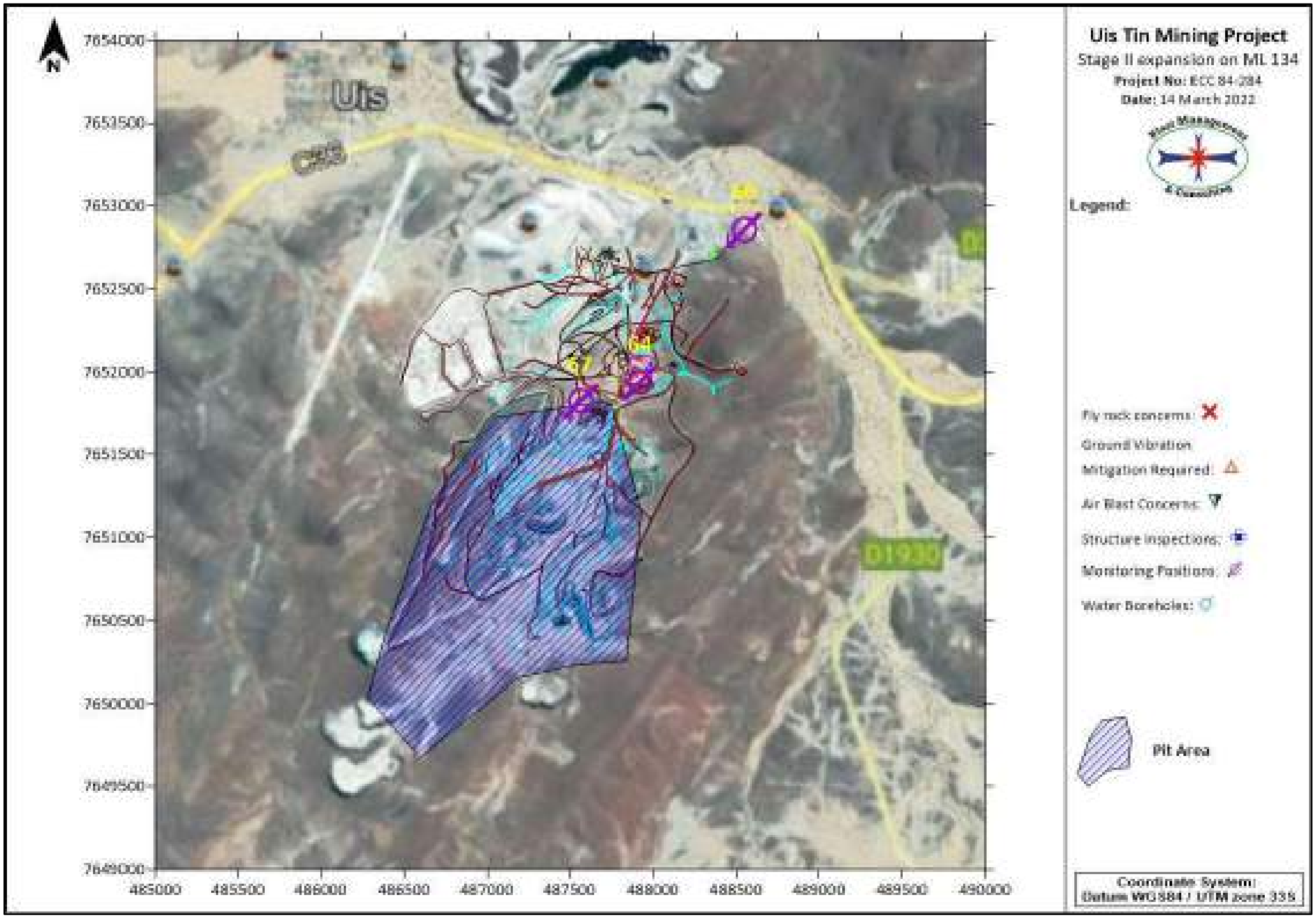


Figure 25: Suggested monitoring positions

Table 24: List of possible monitoring positions

Tag	Description	Y	X
67	Power Lines/Pylons	487564.50	7651824.76
64	Mine Buildings/Structures	487923.27	7651940.61
60	Buildings/Structures	488547.88	7652858.87

18 Recommendations

The following recommendations are proposed.

18.1 500 m general unsafe blasting area

Considering a general accepted rule of 500 m for the unsafe area POI's were identified. Various POI's are observed within the pit that needs consideration as well within 500 m from the mining area. Table 25 shows list of these installations. Figure 26 below shows the 500 m boundary around the opencast pit area. The location of non-mining installations is clearly observed.

Table 25: List of possible installations within the regulatory 500 m

Tag	Description	Y	X
13	Borehole (BH8) - Inside Pit Area	487520.26	7651695.29
16	Borehole (BH11)	487625.96	7651883.51
62	Mine Buildings/Structures	487940.07	7652222.50
63	Mine Buildings/Structures	487882.90	7652244.55
64	Mine Buildings/Structures	487923.27	7651940.61
66	Power Lines/Pylons - Inside Pit Area	487542.63	7651761.39
67	Power Lines/Pylons	487564.50	7651824.76
68	Power Lines/Pylons	487586.39	7651887.09
69	Power Lines/Pylons	487600.88	7651929.21
70	Power Lines/Pylons	487638.52	7651916.64
71	Power Lines/Pylons	487680.28	7651903.04
72	Power Lines/Pylons	487724.69	7651888.20
73	Power Lines/Pylons	487765.92	7651873.84
74	Power Lines/Pylons	487815.39	7651857.83
75	Power Lines/Pylons	487825.12	7651915.85
76	Power Lines/Pylons	487832.86	7651955.23
77	Power Lines/Pylons	487845.02	7652011.67
78	Power Lines/Pylons	487855.36	7652063.02
79	Power Lines/Pylons	487832.24	7652076.86
80	Power Lines/Pylons	487865.32	7652114.09
81	Power Lines/Pylons	487919.46	7652105.13
82	Stormwater Canal	487887.43	7652112.82
83	Stormwater Canal	487983.94	7652141.49
84	Stormwater Canal	488033.59	7652154.15
89	Stormwater Canal	488121.19	7652120.07
90	Stormwater Canal	488140.85	7651979.31
128	Old Sub Station	488125.04	7652048.29
130	Old Abandoned Mine Structures	487551.21	7652087.32
131	Fibre Optical Cable	487850.63	7651959.03
132	Primary Crusher	487940.90	7651990.57

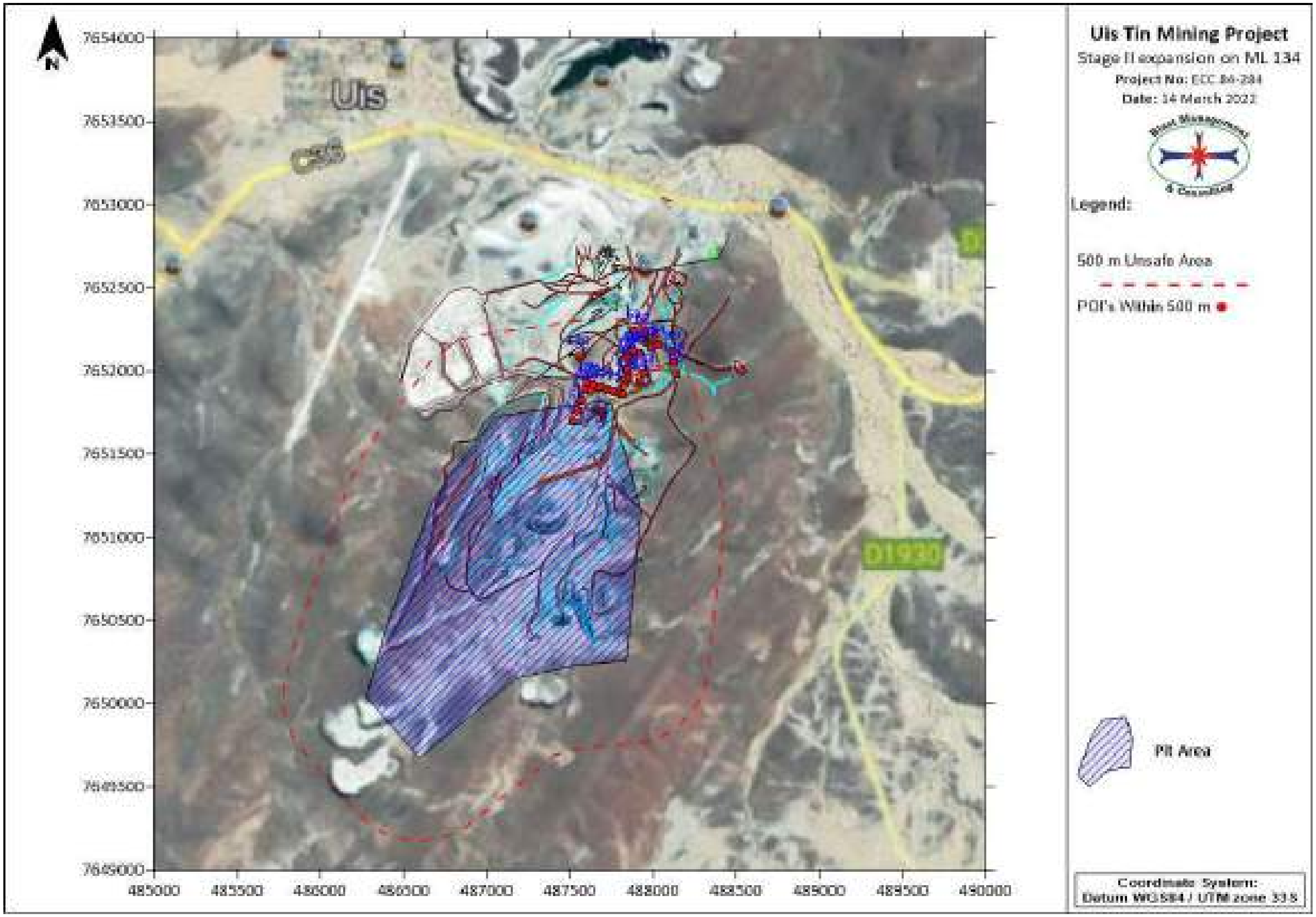


Figure 26: Regulatory 500 m range for the opencast area

18.2 Blast Designs

Blast designs can be reviewed prior to first blast planned and done. Specific attention can be given to the possible use of electronic initiation rather than conventional timing systems. This will allow for single blast hole firing instead of multiple blast holes. Single blast hole firing will provide single hole firing – thus less charge mass per delay and less influence.

18.3 Stemming length

The current proposed stemming lengths used provides for some control on fly rock. Consideration can be given to increase this length for better control. Specific designs where distances between blast and point of concern are known should be considered. Recommended stemming length should range between 20 and 30 times the blast hole diameter. In cases for better fly control this should range between 30 and 34 times the blast holes diameter. Increased stemming lengths will also contribute to more acceptable air blast levels.

18.4 Safe blasting distance and evacuation

Calculated minimum safe distance is 388 m. The final blast designs that may be used will determine the final decision on safe distance to evacuate people and animals. This distance may be greater pending the final code of practice of the mine and responsible blaster's decision on safe distance. The blaster has a legal obligation concerning the safe distance and he needs to determine this distance.

Further it must be confirmed with the respective authorities for the road and the powerlines what the minimum distance between pit and these infrastructure must be. The current distances are very small, and it is certain that the minimum requirements from the authorities will indicate distances further than current.

18.5 Road management

The C35, C36, D1930, D3714 and M76 roads, is at an approximate distance of 2265 m (C35), 1284 m (C36), 1269 m (D1930), 1565 m (D3714) and 2483 m (M76). No specific consideration regarding effects from blasting operations will be required for these roads.

18.6 Recommended ground vibration and air blast levels

The ground vibration and air blast levels limits recommended for blasting operations in this area are provided in Table 26.

Table 26: Recommended ground vibration air blast limits

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
National Roads/Tar Roads:	150	N/A
Electrical Lines:	75	N/A
Railway:	150	N/A
Transformers	25	N/A
Water Wells	50	N/A
Telecoms Tower	50	134
General Houses of proper construction	USBM Criteria or 25 mm/s	Shall not exceed 134dB at point of concern but 120 dB preferred
Houses of lesser proper construction (preferred)	12.5	
Rural building – Mud houses	6	

18.7 Blasting times

A further consideration of blasting times is when weather conditions could influence the effects yielded by blasting operations. It is recommended not to blast too early in the morning when it is still cool or when there is a possibility of atmospheric inversion or too late in the afternoon in winter. Do not blast in fog. Do not blast in the dark. Refrain from blasting when wind is blowing strongly in the direction of an outside receptor. Do not blast with low overcast clouds. These 'do nots' stem from the influence that weather has on air blast. The energy of air blast cannot be increased but it is distributed differently and therefore is difficult to mitigate.
It is recommended that a standard blasting time is fixed and blasting notice boards setup at various routes around the project area that will inform the community of blasting dates and times.

18.8 Third party monitoring

Third party consultation and monitoring should be considered for all ground vibration and air blast monitoring work. This will bring about unbiased evaluation of levels and influence from an independent group. Monitoring could be done using permanent installed stations. Audit functions may also be conducted to assist the mine in maintaining a high level of performance with regards to blast results and the effects related to blasting operations.

18.9 Video monitoring of each blast

Video of each blast will help to define if fly rock occurred and origin of fly rock. Immediate mitigation measure can then be applied if necessary. The video will also be a record of blast conditions.

19 Knowledge Gaps

The data provided from client and information gathered was sufficient to conduct this study. Surface surroundings change continuously, and this should be considered prior to initial blasting operations considered. This report may need to be reviewed and updated if necessary. This report is based on data provided and internationally accepted methods and methodology used for calculations and predictions.

20 Project Result

Specific problems were identified, and recommendations made. The successful resolving of these concerns will allow that the project can be executed successfully with proper management and control on the aspects of ground vibration, air blast and fly rock.

21 Conclusion

Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report evaluates the effects of ground vibration, air blast and fly rock and intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed is typical roads (tar and gravel), low cost houses, corrugated iron structures, brick and mortar houses, communication towers.

The location of structures around the Pit area is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Power Lines, Boreholes and Mine Buildings/Structures. Ground vibrations predicted for the pit area ranged between low and very high. The expected levels of ground vibration for some of these structures are high and will require specific mitigations in the way of adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Air blast predicted also showed more concerns for opencast blasting. The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134dB. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located such that “free blasting” – meaning no controls on blast preparation – will not be possible. The nearest private structures are located 1324 m from pit edge. Air blast levels from maximum charge is expected to be within the accepted limit but slightly greater than 120 dB. This may contribute to some complaints. All other private structures are further away and levels decrease over distance. Levels are expected to be less than 120 dB at distance of 2387 m from the pit edge.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 223 m and closer to pit boundary. Infrastructure at the pit areas such as roads, power lines/pylons are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 388 m. The absolute minimum unsafe zone is then the 388 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Power Lines, Stormwater Canal and Mine Buildings/Structures falls within the 500 m range from the pit area.

The pit areas are located such that specific concerns were identified and addressed in the report.

This concludes this investigation for the proposed Uis Tin Mining Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

22 Curriculum Vitae of Author

J D Zeeman was a member of the Permanent Force - SA Ammunition Core for period January 1983 to January 1990. During this period, work involved testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition.
From July 1992 to December 1995, Mr Zeeman worked at AECI Explosives Ltd. Initial work involved testing science on small scale laboratory work and large-scale field work. Later, work entailed managing various testing facilities and testing projects. Due to restructuring of the Technical Department, Mr Zeeman was retrenched but fortunately was able to take up an appointment with AECI Explosives Ltd.'s Pumpable Emulsion Explosives Group for underground applications.
From December 1995 to June 1997 Mr Zeeman provided technical support to the Underground Bulk Systems Technology business unit and performed project management on new products.
Mr Zeeman started Blast Management & Consulting in June 1997. The main areas of focus are pre-blast monitoring, insitu monitoring, post-blast monitoring and specialized projects.

Mr Zeeman holds the following qualifications:

1985 - 1987	Diploma: Explosives Technology, Technikon Pretoria
1990 - 1992	BA Degree, University of Pretoria
1994	National Higher Diploma: Explosives Technology, Technikon Pretoria
1997	Project Management Certificate: Damelin College

2000 Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997, with work being done at various levels for all the major mining companies in South Africa. Some of the projects in which BM&C has been involved include:

Iso-Seismic Surveys for Kriel Colliery in conjunction with Bauer & Crosby Pty Ltd.; Iso-Seismic surveys for Impala Platinum Limited; Iso-Seismic surveys for Kromdraai Opencast Mine; Photographic Surveys for Kriel Colliery; Photographic Surveys for Goedehoop Colliery; Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village; Photographic Surveys for Aquarius – Everest South Project; Photographic Surveys for Kromdraai Opencast Mine; Photographic inspections for various other companies, including Landau Colliery, Platinum Joint Venture – three mini-pit areas; Continuous ground vibration and air blast monitoring for various coal mines; Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients, e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road; Monitoring of ground vibration induced on surface in underground mining environment; Monitoring and management of blasting in close relation to water pipelines in opencast mining environment; Specialized testing of explosives characteristics; Supply and service of seismographs and VOD measurement equipment and accessories; Assistance in protection of ancient mining works for Rhino Minerals (Pty) Ltd.; Planning, design, auditing and monitoring of blasting in new quarry on new road project, Sterkspruit, with Africon, B&E International and Group 5 Roads; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Pandora Joint Venture 180 houses – whole village; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Section - 1000 houses / structures.

BMC have installed a world class calibration facility for seismographs, which is accredited by Instantel, Ontario Canada as an accredited Instantel facility. The projects listed above are only part of the capability and professional work that is done by BMC.

23 References

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REPUBLIC OF NAMIBIA

MINISTRY OF AGRICULTURE, WATER AND LAND REFORM

Telephone: (061) 2087229
Fax: (061) 2087697
Enquiries: M Nickel
Reference: PC General

Department of Water Affairs
Private Bag 13193
Windhoek
9000

The Director
Afritin Namibia (Pty) Ltd
P. O. Box 90757
Windhoek
Namibia

RE: APPLICATION FOR THE LEGALIZATION OF ONE (1) EXISTING BOREHOLE WITH REGARDS TO THE AMENDMENT OF THE WATER ABSTRACTION PERMIT NO.11 429, AT UIS SETTLEMENT, OMARURU DISTRICT

1. Your application dated 04 August 2021 requesting amendment to your current abstraction permit, No. 11 429, bears reference.
2. The above request is hereby approved by this Ministry for the legalization of borehole number 6 (WW 206113): to be included in permit No. 11 429.
3. Kindly note that all permit conditions as stipulated in abstraction Permit No.11 429 are applicable.
4. You are kindly requested to send page 1 of the permit back to this Ministry for cancellation and to be replaced with the attached page of the permit concerned.
5. This letter now forms part of the permit and must be filed therewith
6. Your co-operation is appreciated.

EXECUTIVE DIRECTOR
2021 -09- 30
Republic of Namibia
Ministry of Agriculture, Water and Land Reform

PERCY W. MISIKA
EXECUTIVE DIRECTOR

REPUBLIC OF NAMIBIA

MINISTRY OF AGRICULTURE, WATER AND LAND REFORM

Telephone: (061) 2087111
Fax: (061) 2087697
Enquiries: M Nickel
Reference: PC General

Department of Water Affairs
Private Bag 13193
Windhoek
9000

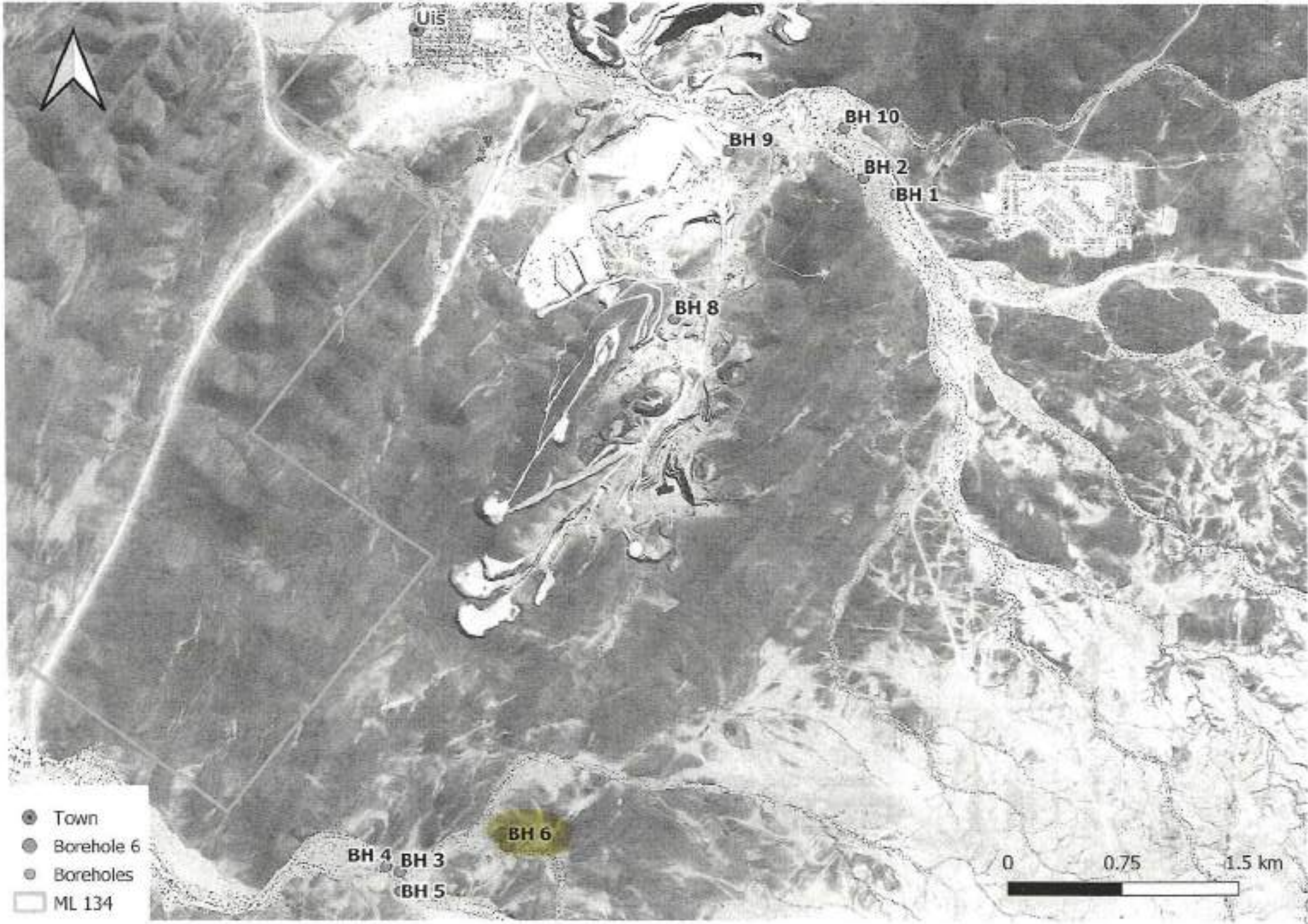
PERMIT NUMBER: 11 429

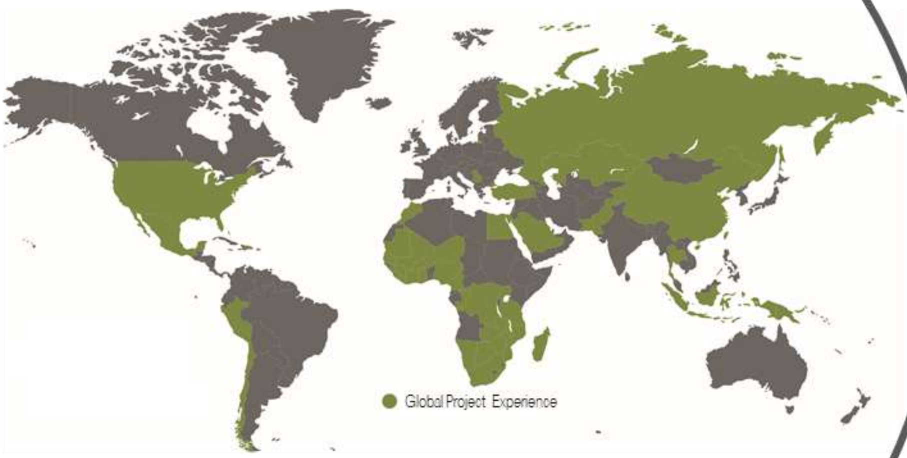
DATE: 15 September 2021

PERMIT ISSUED IN TERMS OF REGULATIONS 5 AND 9 OF GOVERNMENT NOTICE R1278 OF 23 JULY 1971 AS PROMULGATED UNDER SECTION 30(2) OF THE WATER ACT, 1956 (ACT 54 OF 1956), AS AMENDED

NAME OF PERMIT HOLDER	:	Afritin Namibia (Pty) Ltd
ADDRESS	:	P O Box 90757, Windhoek
REGISTERED PROPERTIES	:	Uis Settlement
DISTRICT	:	Omaruru
CONTROL AREA	:	Omaruru Subterranean Water Control Area
VALIDITY PERIOD	:	Two (2) years
BOREHOLES TO BE USED	:	Serial numbers WW 205110, WW 205111, WW 205112, WW 205113, WW 205114, WW 205115, WW 205116, WW 205117 and WW 206113
PURPOSE FOR WHICH WATER MAY BE USED	:	Industrial purposes
ABSTRACTION PER YEAR	:	75 000m³ maximum

This permit authorizes the holder (or his successors in title) to further abstract and use water for the purpose as stated above, from the existing boreholes identified as WW 205110, WW 205111, WW 205112, WW 205113, WW 205114, WW 205115, WW 205116, WW 205117 and WW 206113, as identified on the mine planning map, attached as Annexure A, subject to the following conditions:


Uis
BH 10
BH 9
BH 2
BH 1
BH 8
BH 6
BH 4
BH 3
BH 5
Town
Borehole 6
Boreholes
ML 134
0
0.75
1.5 km



DIGBY WELLS
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1:50 and 1:100 Year Floodline Assessment for the Afritin Mine near Uis Town, Namibia

Surface Hydrology and Floodline Determination Study

Prepared for:
AFRTIN MINING

Project Number:
AFR7554

April 2022

Digby Wells and Associates (South Africa) (Pty) Ltd
Company Registration: 2010/008577/07

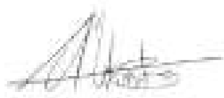
Turnberry Office Park,
Digby Wells House.
48 Grosvenor Road,
Bryanston,2191

Phone: +27 (0) 11 789 9495
Fax: +27 (0) 11 789 9495
E-mail: info@digbywells.com
Website: www.digbywells.com

Directors: J Leaver (Chairman)*,
NA Mehlomakulu*, DJ Otto, M Rafundisani
*Non-Executive

This document has been prepared by Digby Wells Environmental.

Report Type:	Surface Hydrology and Floodline Determination Study
Project Name:	1:50 and 1:100 Year Floodline Assessment for the Afritin Mine near Uis Town, Namibia
Project Code:	AFR7554

Name	**Responsibility**	**Signature**	**Date**
Ofentse Mokonoto Pr.Sci.Nat.	Modelling and Reporting		April 2022
Kevin Bursey Pr.Sci.Nat.	Technical and Report Review		April 2022
Arjan van 't Zelfde	Report Review		April 2022

DETAILS AND DECLARATION OF THE SPECIALIST

Digby Wells and Associates (South Africa) (Pty) Ltd.

Contact person: Ofentse Mokonoto

Digby Wells House
Turnberry Office Park
48 Grosvenor Road
Bryanston
2191

Tel: 011 789 9495
Fax: 011 789 9498
E-mail: ofentse.mokonoto@digbywells.co.za

Brief Background of Specialist

Ofentse Mokonoto is a Hydrologist at Digby Wells Environmental with 8 years working experience. He holds a Master's Degree in Hydrology from the University of KwaZulu-Natal (South Africa). Mr. Mokonoto has been involved and led various projects relating to water resource assessments, flood hydrology, stormwater management plans and water and salt balance modelling. Ofentse has also undertaken surface water specialist studies for input into environmental impact assessments and environmental management plans, Integrated Water and Waste Management Plans (IWWMP), Water Use Licence Applications (IWULA) and auditing. Ofentse has working experience on projects within South Africa, Lesotho, Namibia and Botswana. Ofentse is also a Certified Natural Scientist - Water Resources Sciences (SACNASP).

Full name:	Ofentse Mokonoto
Title/ Position:	Surface Water Consultant
Qualification(s):	Hydrology (MSc)
Experience (years):	8
Registration(s):	South African Council for Natural Scientific Professionals: *Certified Natural Scientist* (Reg. No. 4)

I, **Ofentse Mokonoto**, declare that: –

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

19-04-2022

Signature of the Specialist *Date*

Findings, recommendations and conclusions provided in this report are based on the best available scientific methods and the author's professional knowledge and information at the time of compilation. Digby Wells employees involved in the compilation of this report, however, accepts no liability for any actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, and by the use of the information contained in this document.

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Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or make reference to this report. Whenever such recommendations, statements or conclusions form part of a main report relating to the current investigation, this report must be included in its entirety.

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1 Introduction

Digby Wells Environmental (hereinafter Digby Wells) was appointed by AfriTin Mining (Namibia) (Pty) Ltd (hereinafter AfriTin) to undertake a floodline assessment for the Uis Mine as part of the Environmental Assessment (EA). The 1:50 and 1:100-year return period floodlines were determined for several drainage lines and rivers around the Uis Mine area.

Floodlines determination is used to indicate the level to which a certain flood magnitude will inundate an area along the stream or any watercourse, or which area of land will fall within the floodplain of a particular flood frequency. Flood frequency or the return period (T) is the average period over *n*-years, which an event repeats or exceeds itself; it may be described as the percentage of the annual probability of the occurrence of a flood event.

The process of floodline delineations includes initially calculating the required return period peak discharge value(s) and thereafter hydraulically simulating the peak discharge value along the respective drainage line reaches. As part of the hydraulic simulations, structures located within the drainage lines that are likely to impact the delineated floodlines were included in the hydraulic model (i.e., HEC-RAS).

1.1. Project Background

AfriTin mining recently completed a Definitive Feasibility Study (DFS) for the expansion of its Phase 1 Stage 1 project. The project is a precursor to the long-term Phase 2 expansion, which includes the expansion of the mining area, as well as the development of an additional, full-scale processing plant (AfriTin Mining, 2021). Presently the Phase 1 Stage I project produces approximately 65 tonnes of tin concentrate per month. The expansion of the pilot processing plant for Phase 1 Stage II will increase production to approximately100 tonnes of tin concentrate per month and the Phase 2 expansion plans to increase production to approximately 416 tonnes of tin concentrate per month (AfriTin Mining, 2021).

The focus of this report was to delineate the 1:50 and 1:100-year return period floodlines in the vicinity of the mine. A location map is presented in Figure 1-1.

1.2. Scope of Work

Based on the regulatory requirements, the Scope of Work (SoW) for the current study encompasses the following:

- Site characterisation at desktop level;
- Baseline hydrological assessment;
- Hydraulic modelling; and
- Floodlines determination and mapping

1.3. Assumptions and Limitations

The following are assumptions and limitations of this study:

- The floodlines were developed for environmental and indicative purposes only and not for detailed engineering design purposes;
- The main watercourses traversing through the project area has been considered for floodlines modelling, as it has a sizable contributing catchment. However, drainage lines north of the project area originating along the boundaries of the site were not modelled because they were deemed small and therefore could not collect any significant amount of runoff that can potentially cause flooding;
- It is assumed that survey data obtained from the client is accurate and an up-to-date representation of the ground level terrain;
- A steady-state (1-dimensional/1-D) hydraulic model was run, which assumes that flow is continuous at the determined peak flow rates. This is a conservative approach, which results in higher flood levels than if transient state modelling was performed;
- The lidar survey provided is assumed to represent the terrain/elevations and other features correctly (e.g., berms);
- The berms should cover all the areas that are prone to flooding, such as the open pit;
- The floodlines were modelled for sections of the unnamed streams traversing through the project area and only within the boundaries of the surveyed area;
- No abstractions from the river section or discharges into the river section were considered during flood modelling; this study only focuses on the floodlines scenarios and;
- Although flood calculations are executed with great care, the possibility always exists that a more severe flood could occur or that flooding as a result of non-hydrological events could take place.

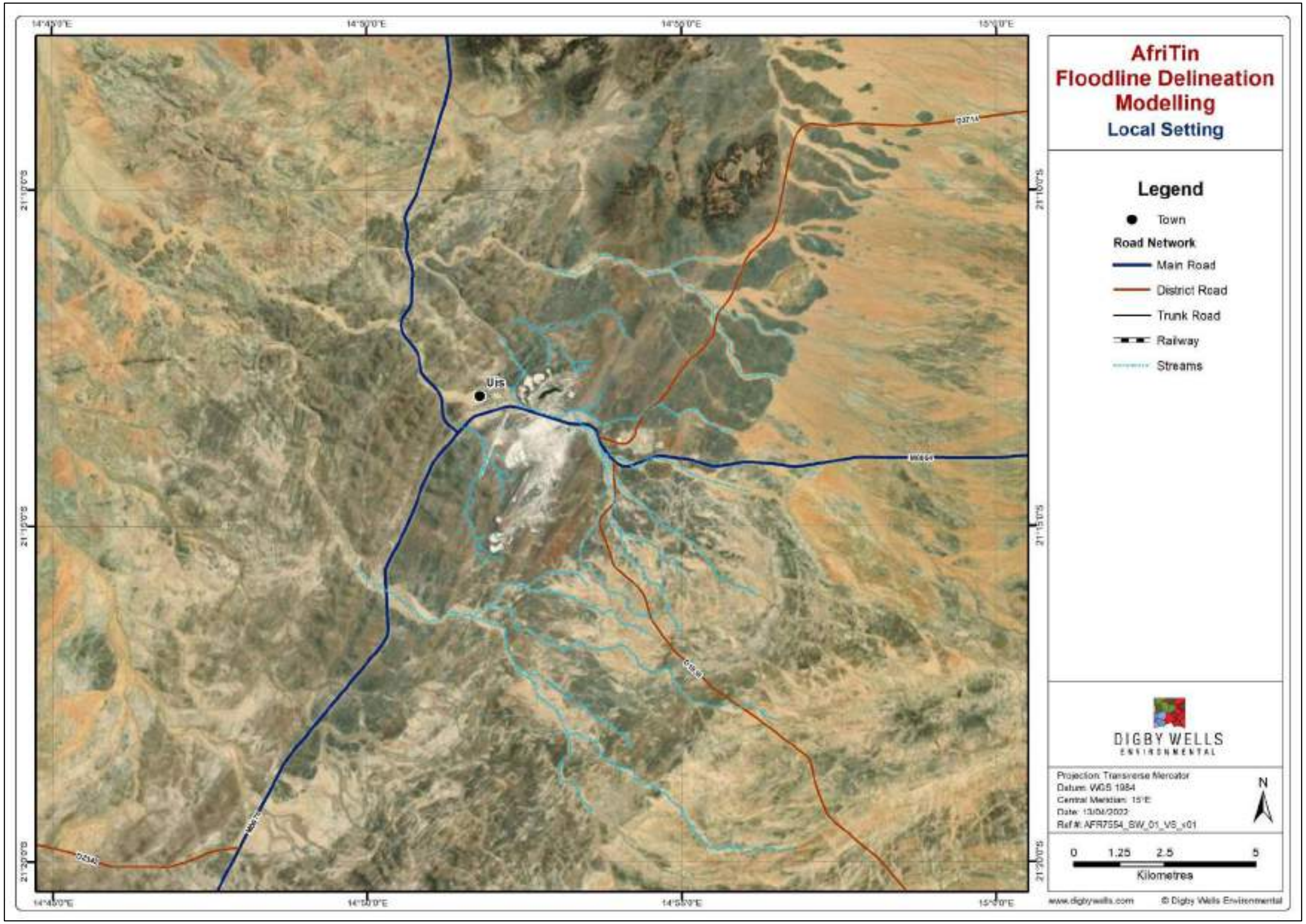


Figure 1-1: Locality of the Uis Mine Project Site Showing the Surrounding Streams

2. Relevant Legislation

There are no guidelines for developments in terms of floodlines in Namibia as such the South African National Water Act (Act 36 of 1998) (hereafter referred to as SA NWA) as well as the Government Notice 704 (Government Gazette 20119 of June 1999) (hereafter referred to as GN704), The British guidelines and the International Finance Corporation (IFC). The guidelines deemed applicable in this floodline assessment are presented below.

2.1. National Water Act

The National Water Act (Act No. 36 of 1998), states that "For the purposes of ensuring that all persons who might be affected have access to information regarding potential flood hazards, no person may establish any development unless the layout plan shows, in a form acceptable to the local authority concerned, lines indicating the maximum level likely to be reached by floodwaters on average once in every 100 years".

2.1.1. Regulations on the use of Water for Mining and Related Activities

GN 704 was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. The main conditions of GN704 applicable to this project is:

- Condition 4 – indicates that no person in control of a mine or activity may locate or place any residue deposit, dam, reservoir, together with any structure of other facility within the 1:100-year flood line or within a horizontal distance of 100-metre from any watercourse.

2.2. International Finance Corporation (IFC) Guidelines: Environmental, Health and Safety Guidelines for Mining (2007)

The IFC guidelines does not provide guidance on floodline modelling and recurrence interval. However, it provides the following guidelines in terms of development within or near a flood line:

- Design specification should take into consideration the probable maximum flood event and the required freeboard to safely contain it (depending on site-specific risks) across the planned life of the tailings dam, including its decommissioned phase.
- Design of tailings storage facilities should consider the specific risks/hazards associated with geotechnical stability or hydraulic failure and the associated risks to downstream economic assets, ecosystems and human health and safety. Environmental considerations should thus also consider emergency preparedness and response planning and containment/mitigation measures in case of a catastrophic release of tailings or supernatant waters.

2.3. IFC Guidance Notes to Performance Standards on Environmental and Social Sustainability (2012)

The performance standards of the IFC Guidance noted that a "projects potentially subject to coastal or river flooding or landslides, should evaluate potential impacts due to predicted or observed changes in hydrology, including a review of reasonably accessible historical hydrologic information (including frequency and intensity of hydrologic events) and scientifically projected trends. The evaluation of climate-related risks should include a discussion of potential changes in hydrologic scenarios, and the resulting potential impacts and mitigation measures considered in the design and operation of the project. This evaluation shall be commensurate with the availability of data and with the scale of the potential impacts" (IFC, 2012).

2.4. British Columbia (BC) Flood Hazard Area: Land Use Management Guidelines (2018 Amendment)

BC (2018) indicates that flood assessments that pertain to development approval must comply with legislative requirements (federal and/or provincial). It further indicates that flood assessment reports must also comply with local bylaw requirements (recognizing that they typically include a formal process for variance or relaxation).

Standard requirements for ordinary watercourses

It should be noted that the natural boundary for watercourses includes the best estimate of the edge of dormant or old side channels. The standard requirements as per the BC guidelines are as follows:

- A flood plain map that delineates the area that can be expected to flood, on average, once every 200 years (called the 200-year flood) should be developed. In the context of this study, the 1:50 and 1:100-year floodlines were calculated and will be used as a guideline to measure the impact of flooding because of the non-perennial nature of the streams as well as the absence of a long record of streamflow data.
- Buildings should be setback at least 30-metres from the natural boundary of any watercourse. Where non-standard dikes exist, setbacks should be developed in consultation with the Inspector of Dikes in order to provide right-of-way for any future dike improvements and/or access.

3. Methodology

3.1. Baseline Hydrology

This section provides the methodology used in determining the hydrological characteristics of the project area and region. This includes climatic data (rainfall and temperature), calculations of the peak flows and floodlines modelling.

3.1.1. Climate

Climate data was obtained from the Climate Forecast System Reanalysis (CFSR). CFSR is a global, high resolution, coupled atmosphere-ocean-land surface-sea ice system designed to provide the best estimate of the state of these coupled domains between 1979 to 2014 (National Centre for Atmospheric Research, 2022).

3.1.2. Catchment Delineation

Catchment delineation was undertaken in Ras Mapper using the lidar survey received from the Client. This dataset was stored in a raster GeoTIFF format referenced to the central meridian 33 Datum (UTM 33S Projection).

3.1.3. Peak Flows

Peak flow estimates for the delineated catchments were calculated using the Utility Program for Drainage (UPD) software. Widely used and recommended design flood estimation methods were used to calculate the 1:50-year and 1:100-year peak flows for the delineated catchments at the project site. The peak flow methods are summarised below:

Rational Method (Alternative 2): The Rational Method Alternative 2 (RM2) is described by the formula Q = CIA, where I is rainfall intensity, A is the runoff contributing area, C is the runoff coefficient and Q is the peak flow**.** RM2 uses the modified recalibrated Hershfield relationship to determine point rainfall. Design rainfall depths were calculated using the TR102 representative rainfall data (SANRAL, 2013).

Standard Design Flood Method: The Standard Design Flood (SDF) method is an empirical regionally calibrated version of the Rational Method (SANRAL, 2013). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions. The design methodology is slightly different and looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities (SANRAL, 2013). The information required in this method is the area of the catchment, the length and slope of the mainstream and the drainage basin in which it is located.

Unit Hydrograph: The Unit Hydrograph (UH) method is suitable for design flood estimation in catchments with areas ranging between 15 km^2 and 5 000 km^2. The UH Method is based mainly on regional analyses of historical data and is independent of personal judgement. The results are reliable, although (mainly in catchments smaller than 100 km^2) some natural variability in the hydrological occurrences is lost through the broad regional divisions and the averaged form of the hydrographs (SANRAL, 2013).

Midgley & Pitman: The Midgley and Pitman (MIPI), which is an empirical method, is based on correlation between peak flows and some catchment characteristics which include the effective catchment area, length to catchment centroid, MAP and a derived constant (K_T) for a T-year return period. Regional parameters are then mapped out for South Africa. However, MIPI is applicable in Namibia. These methods are mostly suitable for medium to large catchments (SANRAL, 2013). MIPI is particularly for obtaining an advance indication of the order of magnitude of peak discharges, serving as a rough check on the results of non-statistical methods (SANRAL, 2013).

3.1.3.1. Land Cover and Soils

Land cover and soil data are necessary for peak flow calculations since they determine the potential for infiltration and overland flow. Google Earth Imagery (2021) was used to determine the type of land cover across the delineated catchments. Soil information was inferred from the Soil Conservation Service – South Africa (SCS-SA) database.

3.2. Floodlines

Hydraulic modelling was conducted in HEC-RAS 6.0.2 which allows pre-processing within the in-built RAS Mapper module. A digital elevation model (DEM) was generated from the lidar survey for the area to make the topographic data compatible with RAS Mapper. The pre-processing involved generation of the channel geometry, including the river network, banks, flow paths and cross-sections. The new geometry was opened in HEC-RAS where hydraulic analysis occurred.

The HEC-RAS model simulates the total energy of water by applying basic principles of mass, continuity and momentum as well as roughness factors between all cross-sections (US Army Corps of Engineers, 1995). A height is calculated at each cross-section, which represents the level to which water will rise at that section, given the potential peak flows. This was calculated for the 1:50-year and 1:100-year flows on all river sections.

Analyses are performed by modelling flows at the sub-catchment outlet of a particular stream or channel sections first, moving upstream. Manning's Roughness Coefficients (n) for the channels were set at 0.04, and those for riverbanks were determined to be 0.045 representing natural channels with reeds and brush on the banks (Chow, 1959). These coefficients were selected based on the Cowan Theory (Cowan, 1956) according to the following equation:

$$\boldsymbol{n = (nb + n1 + n2 + n3 + n4)m} \quad \textbf{(1)}$$

where:

- n_b is a base value of roughness for a straight, uniform, smooth natural channel;
- n_1 is a correction factor for the effect of surface irregularities;
- n_2 is a value depicting channel cross-sectional area variations in shape and size;
- n_3 is a value for flow obstructions in the channel;

- n_4 is a value for vegetation and flow conditions, and
- m is a correction factor for the meandering of the channel.

Physical factors in the assessed channel were used to estimate roughness adjustment factors, as described in the aforementioned equation (Cowan, 1956).

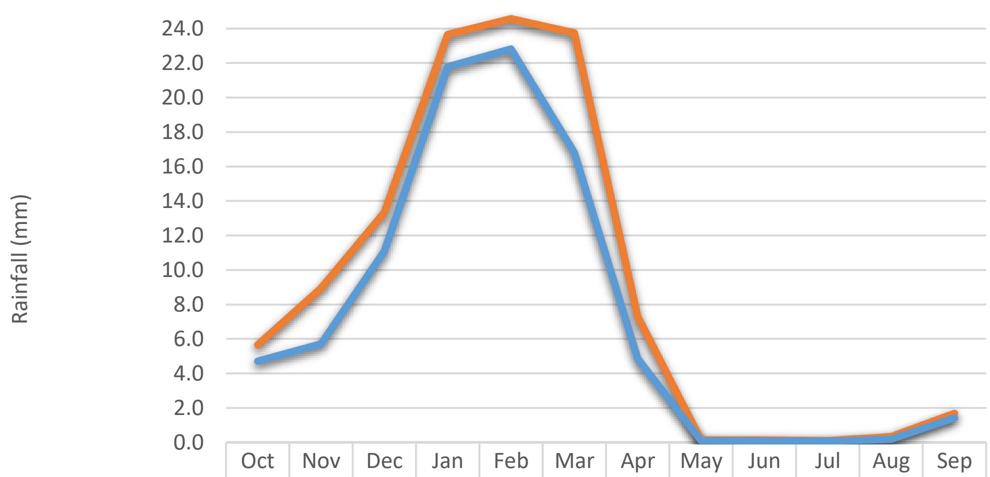
4. Baseline Hydrology

According to the Köppen climate classification, Uis is a hot desert climate (BWh). The BWh classification characterises areas where evaporation and transpiration exceed precipitation with hot to exceptionally hot (over 40°C) periods of the year. Climate data was collected from two weather stations around the project area, which have daily rainfall and temperature data between 1979 and 2014.

4.1.1. Rainfall

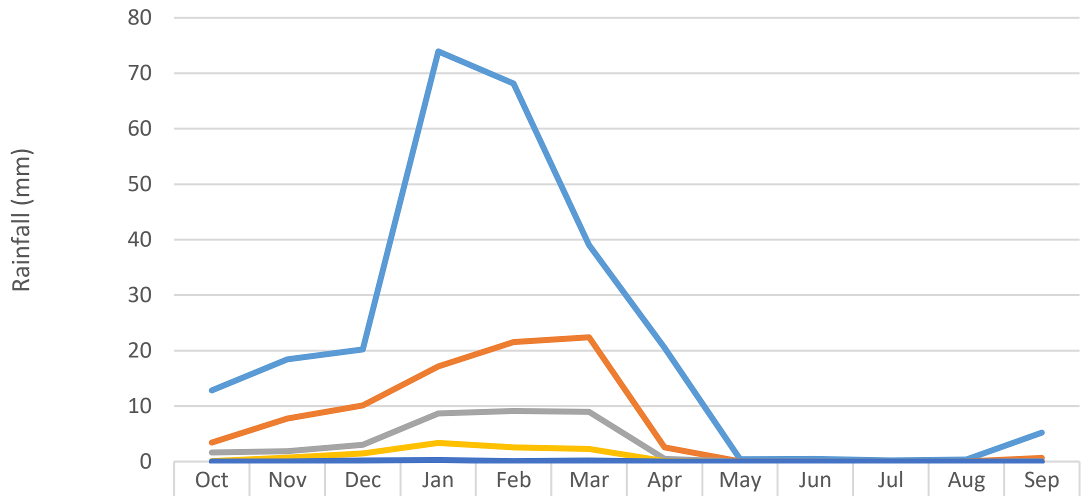
The distribution of rainfall is extremely seasonal with almost all the rain falling in summer (October to April) with the months of January to March receiving the highest rainfall while the remaining months mark the dry season. The rainfall data is presented in Figure 4-1. The Mean Annual Precipitation (MAP) for rainfall stations 211147 and 214150 is 83 mm/year and 90 mm/year, respectively. According to a report by AfriTin (AfriTin Mining, 2021), the project site receives a MAP ranging between 50 to150 mm, and the mean annual evaporation is between 3200 to 3400 mm. Therefore, the project site experiences extremely high annual evaporation compared to the annual rainfall.

Quantile rainfall distributions at the site indicate that the normal rainfall (70% of the events) for the wettest month will range between 22 mm and 25 mm, while extreme rainfall (10% of the events) will range between 74 mm and 98 mm. This implies that the region experiences low rainfall (see Figure 4-2 and Figure 4-3).



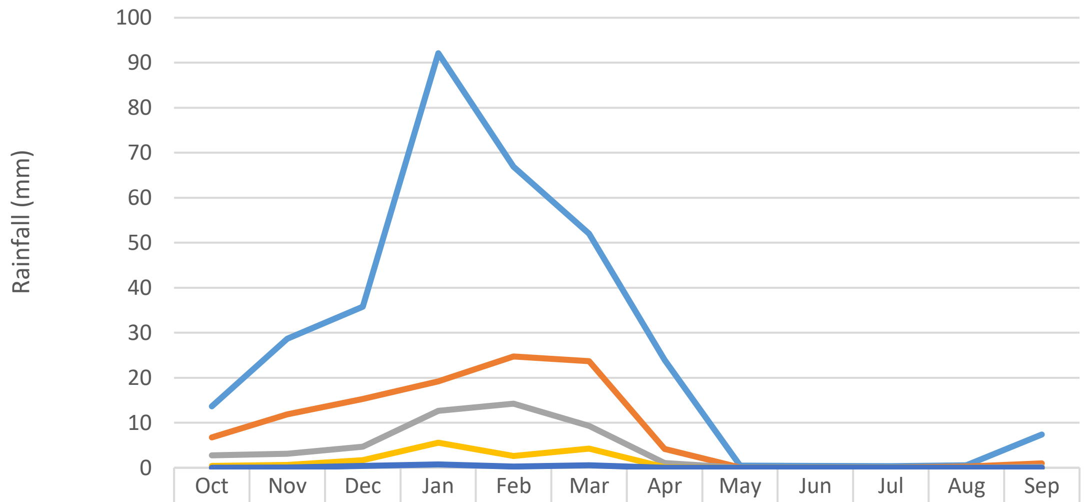
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Rainfall (mm) - Station 211147	5.7	8.9	13.3	23.7	24.6	23.8	7.3	0.1	0.1	0.1	0.3	1.7
Rainfall (mm) - Station 214150	4.7	5.7	11.1	21.8	22.8	16.8	4.9	0.1	0.1	0.1	0.2	1.4

Figure 4-1: Rainfall Trends of Rainfall Station 211147 and 215150



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
90 Percentile	13	18	20	74	68	39	21	0	1	0	0	5
70 Percentile	3	8	10	17	22	22	3	0	0	0	0	1
50 Percentile	2	2	3	9	9	9	1	0	0	0	0	0
30 Percentile	0	1	1	3	3	2	0	0	0	0	0	0
10 Percentile	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4-2: Quantile Rainfall Distribution for the Project Site (Rainfall Station 214150)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
90 Percentile	14	29	36	92	67	52	24	0	0	0	1	7
70 Percentile	7	12	15	19	25	24	4	0	0	0	0	1
50 Percentile	3	3	5	13	14	9	1	0	0	0	0	0
30 Percentile	0	1	2	6	3	4	0	0	0	0	0	0
10 Percentile	0	0	0	1	0	1	0	0	0	0	0	0

Figure 4-3: Quantile Rainfall Distribution for the Project Site (Rainfall Station 211147)

4.1.2. Temperature

A summary of the temperature data obtained from CFSR is presented in Table 4-1. The monthly distribution of average daily maximum temperatures shows that the average midday temperatures range between 19.5°C in July to 29.9°C in March. The region records its coldest average temperatures during June and July with the temperature dropping to 11.8°C on average during the night. On average the hottest months are in the summer months between October to March.

Table 4-1: Temperature Data from 1979 – 2014

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temperature (°C)	25.3	26.3	26.9	25.1	22.0	19.5	19.8	21.6	23.9	24.5	24.9	24.8
Average Minimum Temperature (°C)	16.5	18.0	19.2	17.5	14.5	11.9	11.8	12.5	14.0	14.5	15.1	15.2
Average Maximum Temperature (°C)	34.1	34.6	34.7	32.7	29.6	27.1	27.8	30.6	33.7	34.5	34.8	34.5

4.2. Topography and Drainage

The town of Uis is located within the Uis River which is a tributary within the Ugab Catchment Area. The Uis River drains the project area in a north-westerly direction until it joins the Ugab River. The Ugab River is the main river that drains the Ugab Catchment which has an area of ~29 000 m^2 (AfriTin Mining, 2021). Although the town of Uis is located in the Ugab Catchment Area, the town receives water from the Omaruru River. The Omaruru River drains the Omaruru Catchment which has an area of ~11 500 m^2 and receives an annual rainfall of between ~300 - 350 mm from the mountainous region upstream (AfriTin Mining, 2021).

4.3. Catchment Delineation

Six catchments were delineated for modelling purposes for the streams that are in the vicinity project site (see Figure 4-4). The catchments' characteristics are shown in Table 4-2.

Table 4-2: Characteristics of the Delineated Catchments

Catchment	Area (km^2)	Length of longest watercourse (km)	Distance to catchment centroid (km)	Equal area height difference	Slope (m/m)
C1	83.3	20.7	11.0	204.1	0.013
C2	69.4	16.7	7.9	156.7	0.012
C3	12.1	10.2	4.5	97.0	0.032
C4	5.4	4.5	2.1	42.7	0.004
C5	0.2	0.8	0.4	6.4	0.011
C6	0.9	1.7	1.5	32.6	0.041

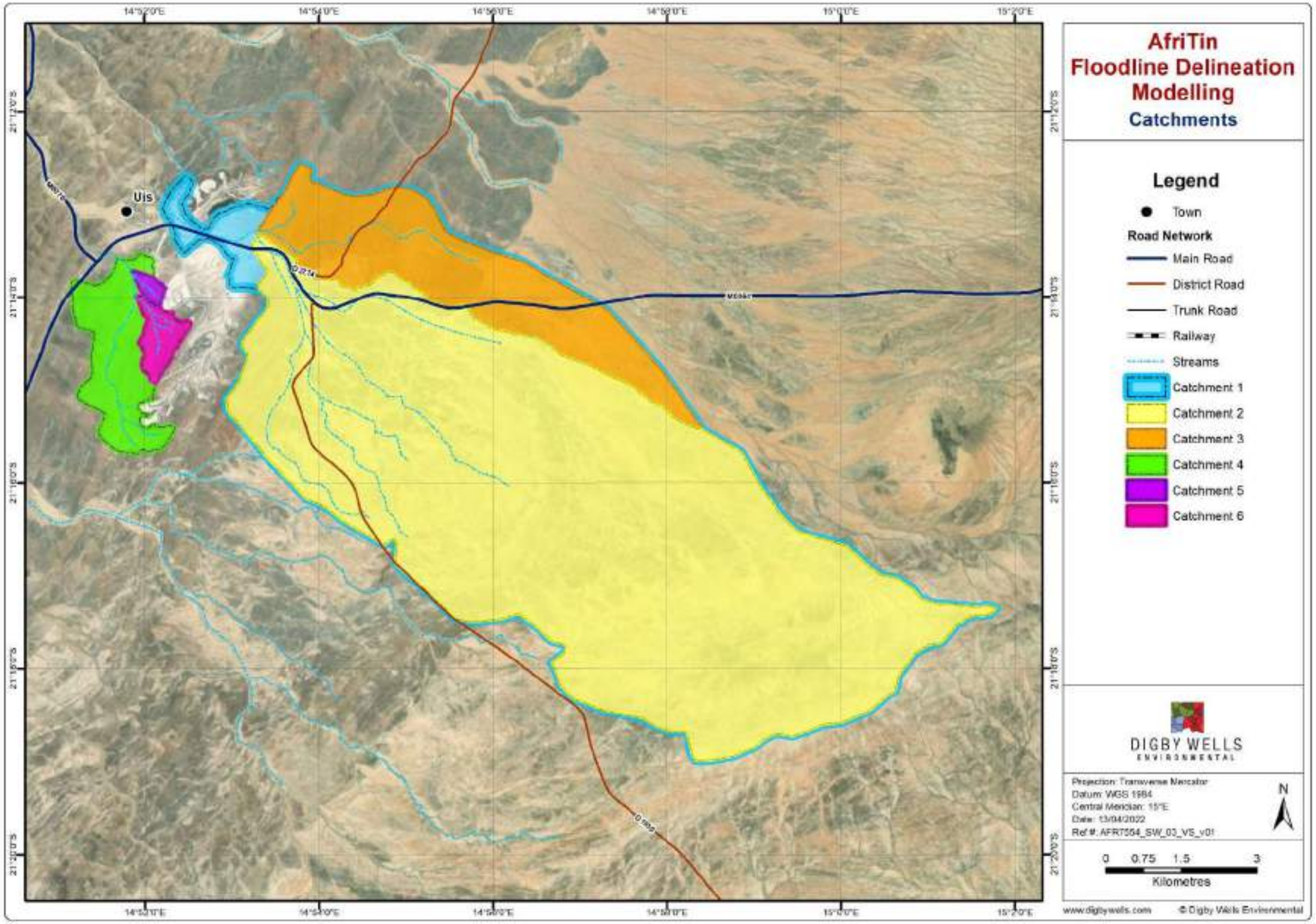


Figure 4-4: Delineated Catchments in the Vicinity of the Project Site

4.4. Design Rainfall Depths

Design rainfall depths, for a 24-hour duration, from the UPD were compared to the statistically derived rainfall depths from the daily rainfall stations obtained from the CFSR (see Table 4-3). The recent high rainfall events in Uis in January and February were included in the daily rainfall data received from CFSR to estimate the 24-hour duration design rainfall depths. On 19 January 2022 and 13 February 2022, Uis received about 30 mm and 40 mm of rainfall in a day, respectively.

From the results in Table 4-3, it is noted that the CFSR rainfall stations' design rainfall depths are almost similar to those of Rainfall Station 131639 W. Therefore, Rainfall Station 131639 W selected in the UPD was deemed to represent the design rainfall depths of the Uis region fairly well.

Table 4-3: 24-Hour Design Rainfall Depths

Return Period (Years)	2	5	10	20	50
Rainfall Station 131639 W	23.0	35.0	45.0	56.0	74.0
CFSR Rainfall Station 214150	15.4	31.5	45.2	61.4	87.7
CFSR Rainfall Station 211147	16.0	29.5	39.7	50.5	66.3

4.5. Peak Flows

Design peak flows for the 1:50 and 1:100-year recurrence interval storm events were computed for the watercourses in the study site using the methodologies listed in 3.1.3. This was undertaken to compare the results obtained by these methods. The comparison of the different flood peaks, using different methodologies can be seen in Table 4-4.

There is a wide range of peak discharge results obtained from the different methods. The differences in results from the deterministic methods, namely the Unit Hydrograph and Rational Methods, were expected given the difference in methods in determining point rainfall as well as catchment sizes. The Rational Method is best suited for catchment sizes of up to 15 km^2 as noted by the SANRAL Drainage Manual (2013). Additionally, slight changes in the input variables such as the areal reduction factor or the catchment C Factor can result in significant changes in the resultant peak discharge value. The Unit Hydrograph Method, on the other hand, was developed for catchment areas ranging between 15 and 5 000 km^2. The results of this method were found to be less conservative than those obtained from the Rational Method as well as the SDF and MIPI. The SDF results are considered conservative, particularly for the larger C1 and C2 catchments. The RM2 flood peaks are also conservative, and the peaks are not far-off from the SDF peaks.

Overall, because the RM2 method was developed for small rural catchments and produced conservative peak flows, those peaks were selected for use in HEC-RAS for hydraulic modelling.

Table 4-4: Peak Discharge Results for the Delineated Catchments

Catchment	Rational Method (RM2)		Unit Hydrograph (UH)		Standard Design Flood (SDF)		MIPI	
Return Period	1:50-year	1:100-year	1:50-year	1:100-year	1:50-year	1:100-year	1:50-year	1:100-year
	(m^3/s)							
C1	51.0	61.2	29.1	40.6	53.8	68.2	34.4	43.7
C2	50.1	60.8	18.9	41.0	49.1	62.1	32.7	41.5
C3	14.9	18.0	6.0	8.5	12.2	15.5	10.0	12.7
C4	11.1	13.5	6.2	8.9	8.9	11.3	7.3	11.3
C5	1.0	1.2	0.2	0.3	0.8	1.1	1.1	1.4
C6	4.2	5.1	1.2	1.7	3.1	3.9	2.8	3.6

5. Floodlines Determination

Floodlines were modelled for the 1:50-year and 1:100-year flood events. The streams included in the analysis were those agreed upon by Digby Wells and the Client in the proposal phase of this study, augmented by the study boundary and the DEM. The inundation extents overlaid on the sections of these unnamed streams traversing through the proposed project boundary are indicated in Figure 5-1 and Figure 5-2. The HEC-RAS cross-sections are shown in Appendix A.

The results indicate that the modelled floods will mostly not inundate the mining area and surrounding infrastructure. The flood protection berms, shown in Figure 5 1, can divert floodwaters away from the mine property. For discussion purposes, the impacts of Berms 8, 2 and 4 are shown in Figure 5-3 to Figure 5-6. At Berm 8, the floodwaters are diverted away from the mining area which is situated at a lower elevation. However, where Berm 8 ends, the modelling indicates that both the 1:50 and 1:100-year floodlines would flood the pit (see Figure 5-4).

The lidar survey indicates that Berm 8 is at an elevation of 807 m Above Mean Sea Level (AMSL) and the natural ground is at an elevation of 805.6 m AMSL. Therefore, the modelling shows that the floodwaters would start flowing into the pit at the lower natural ground (just after Berm 8). To minimise the possibility of flooding into the pit area, it is recommended that Berm 8 is extended around the pit. Berm 2 and Berm 4, which are located near Uis town, also act as flood protection barriers which divert water away from the road and Uis town (see Figure 5-5 and Figure 5-6). The model also indicates that the culvert along the road (between Berm 7 and Berm 10) would be overtopped by both the 1:50 and 1:100-year floodlines. The culvert was likely designed for lower return period floodlines such as the 1:20 year return period.

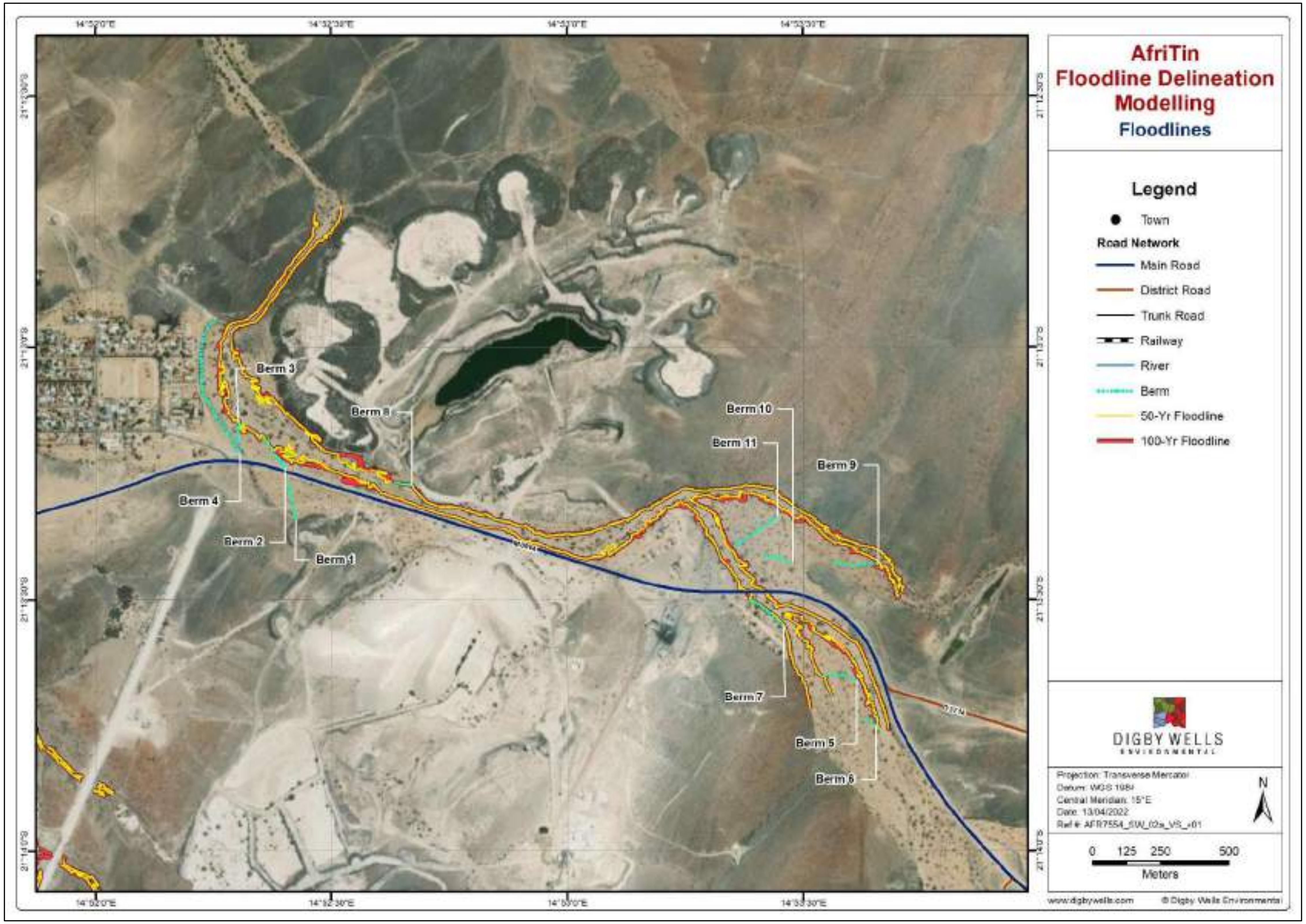


Figure 5-1: Floodlines for the 1:50-year and 1:100-Year Events (North of the M0064 Road)

Figure 5-2: Floodlines for the 1:50-year and 1:100-Year Events (South of the M0064 Road)

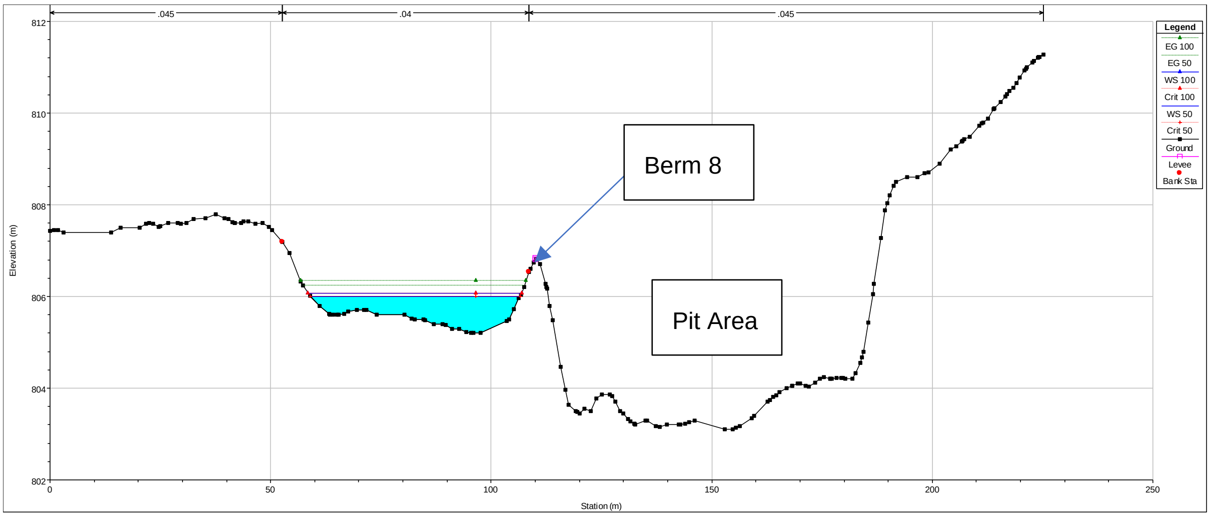


Figure 5-3: Modelled Floodwaters in the vicinity of Berm 8 (Represented by a Levee)

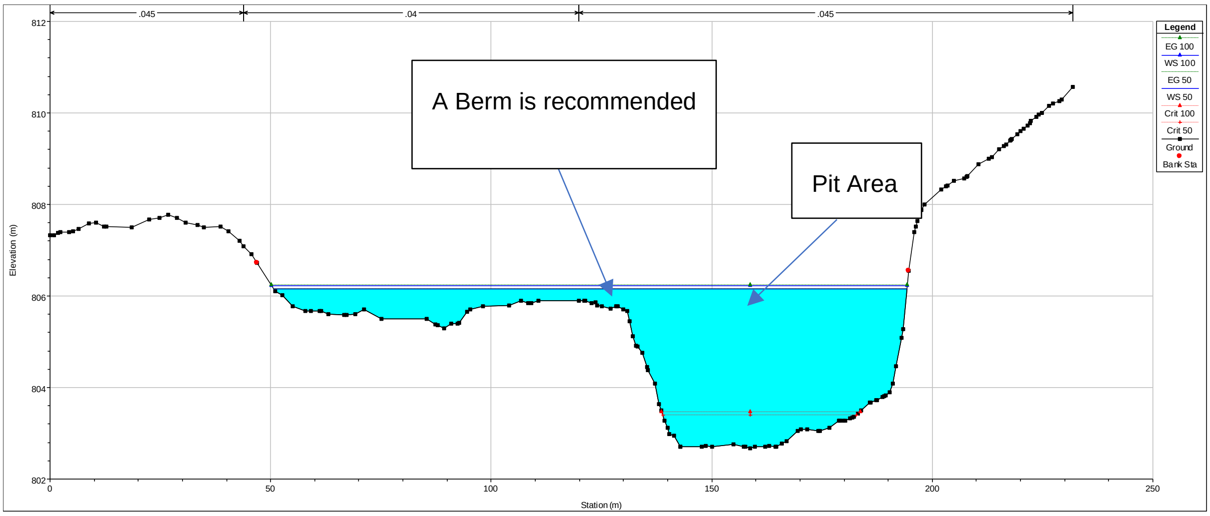


Figure 5-4: Modelled Floodwaters just Downstream of Berm 8

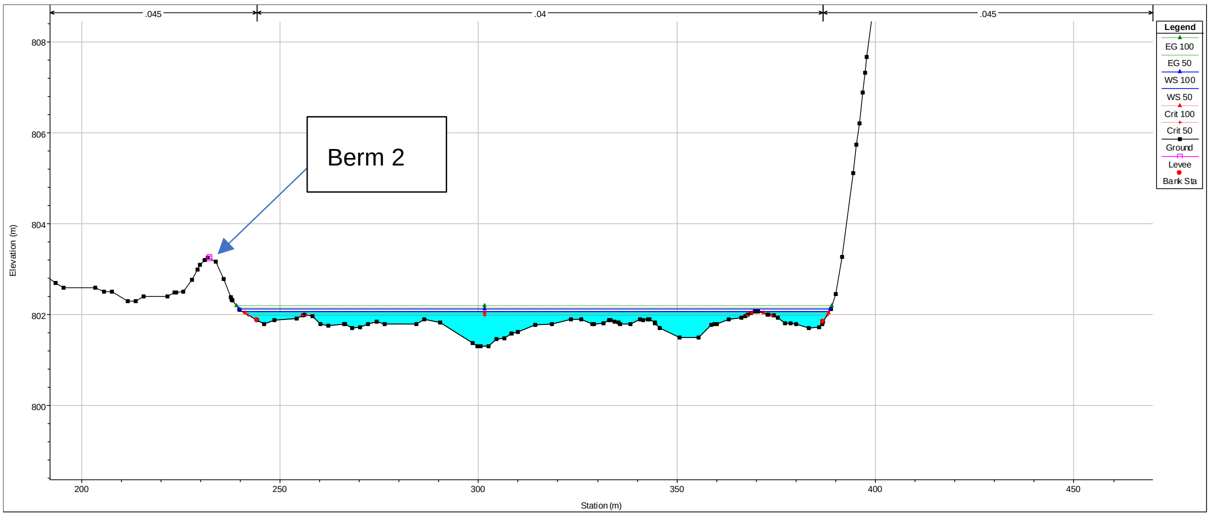


Figure 5-5: Modelled Floodwaters in the Vicinity of Berm 2 (Represented by a Levee)

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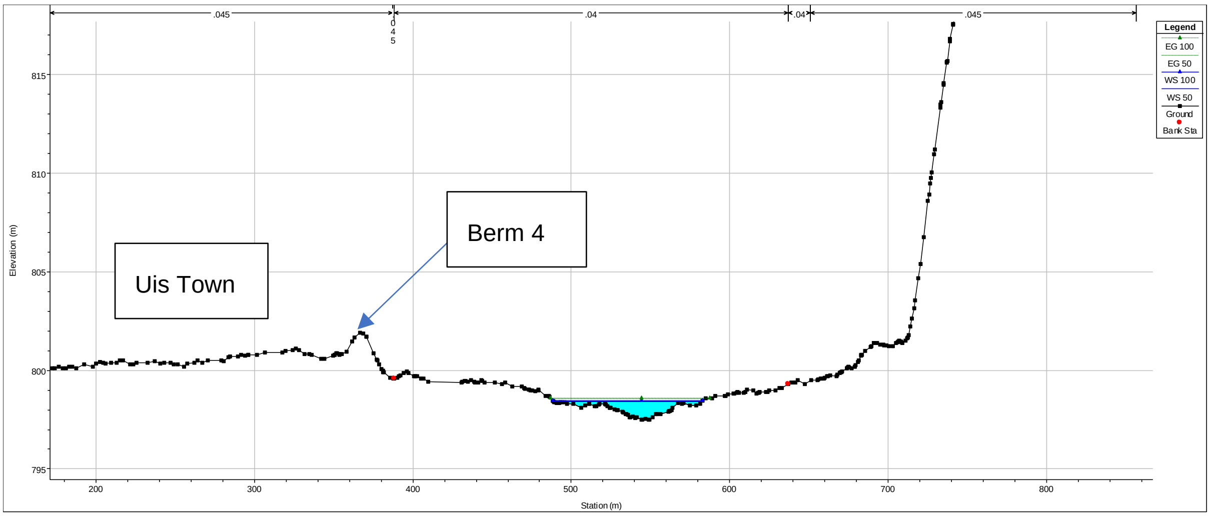

Figure 5-6: Modelled Floodwaters in the Vicinity of Berm 4

6. Conclusions and Recommendations

- The study has modelled the 1:50-year and 1:100-year flood events, which subsequently indicate the potential inundation of the modelled streams during these rainfall events;
- The 1:50 and 1:100-year return period peak discharge values for the identified streams were calculated using the Rational Method Alternative 2 (RM2) which was compared to other design rainfall estimation methods and its peak discharges were deemed conservative and representative of the study site;
- The modelled floodlines using the HEC-RAS model were deemed representative;
- The results of the HEC-RAS model indicate that the modelled floods will not inundate the mining area and its infrastructure;
- The flood protection berms that are in place are able to divert floodwaters away from the mine property;
- However, it is recommended that Berm 8 is extended around the open-pit area to divert floodwater away;
- The modelled floodlines will assist when determining the placement of infrastructure for the protection of water resources, as required by various legislations;
- The indicative floodline results presented in this study are as accurate as the lidar survey, but they should be sufficient to meet the relevant environmental requirements;
- It is recommended that should there be any changes in the terrain of the mining area, these floodlines should be updated.

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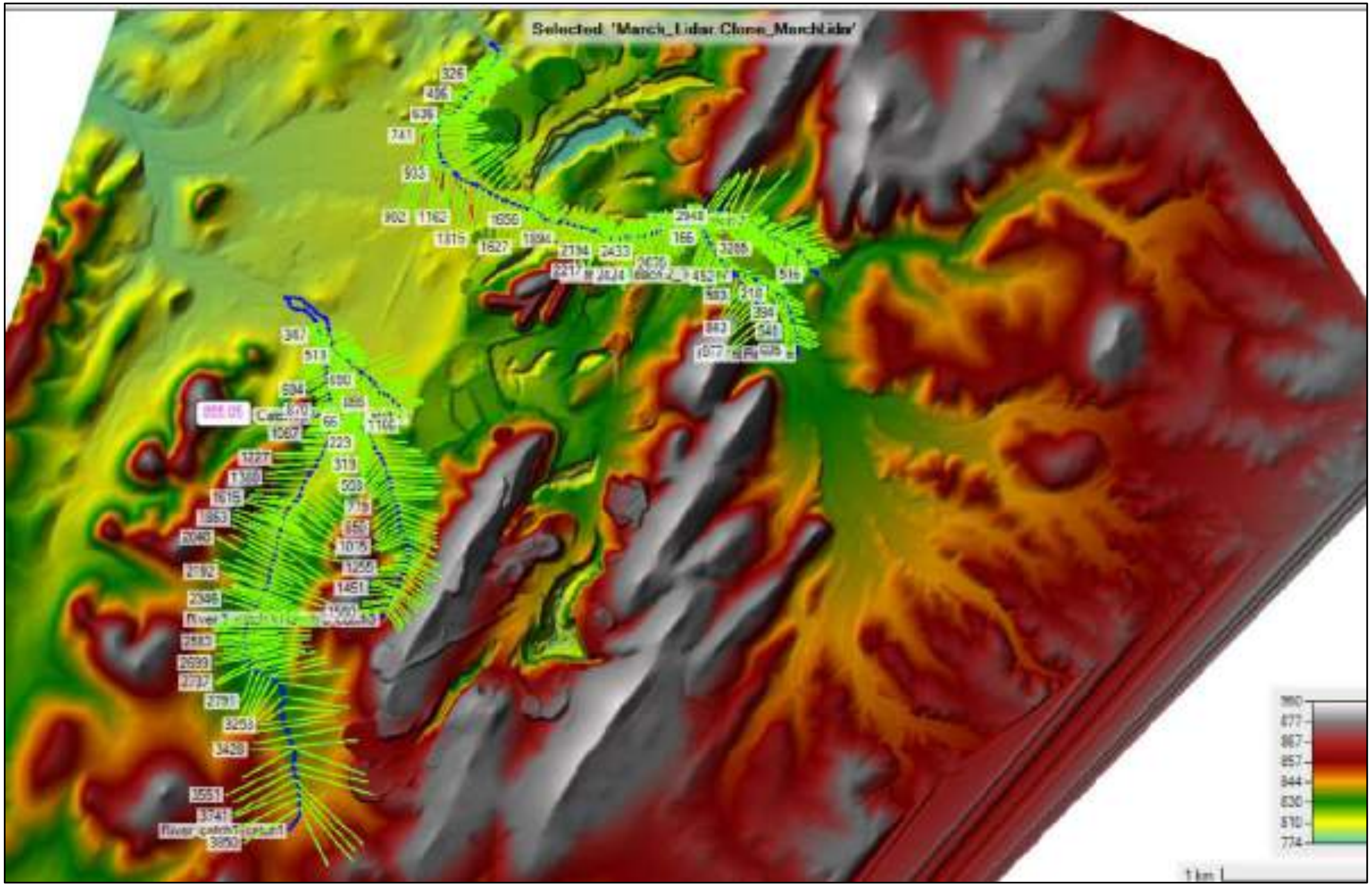
Appendix A: HEC-RAS Cross-Sections



Appendix A1: Cross-Sections Along the Digitized Streams

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Groundwater Supply Investigation for the Uis Tin Project, Namibia

Geophysical Survey Report

Prepared for:
AfriTin Mining (Namibia) (Pty) Ltd

Project Number:
AFT7220

June 2022

Digby Wells and Associates (Pty) Ltd
Company Registration: 1999/005985/07

Turnberry Office Park,
Digby Wells House.
48 Grosvenor Road,
Bryanston,2191

Phone: +27 (0) 11 789 9495
Fax: +27 (0) 11 789 9498
E-mail: info@digbywells.com
Website: www.digbywells.com

Directors: J Leaver (Chairman)*,
NA Mehlomakulu*, DJ Otto, LF Stevens,
GE Trusler, RA Williams*
*Non-Executive

This document has been prepared by Digby Wells Environmental.

Report Type:	Geophysical Survey Report
Project Name:	Groundwater Supply Investigation for the Uis Tin Project, Namibia
Project Code:	AFT7220

Name	Responsibility	Signature	Date
Megan Edwards	Report Writer		30 June 2022
Andre van Coller	Report Review		30 June 2022

EXECUTIVE SUMMARY

Digby Wells Environmental (hereinafter Digby Wells) was appointed by AfriTin Mining (Namibia) (Pty) Ltd (hereinafter AfriTin) to undertake a water supply assessment for the planned expansion of production at the Uis Tin Mine, in Namibia. A parallel investigation is confirming if the ten (10) boreholes AfriTin currently have near to the mine, could potentially cover the Phase 1 (Stage I and II) water requirements. The focus of this report, therefore, is on locating potential drilling targets within the regional aquifers surrounding the mine to provide an additional source of groundwater for the Phase 2 expansion and/or supplement the Phase 1 (Stage II) expansion requirements should the current boreholes be insufficient for this requirement.

The study area is in the Damara Orogen, which is an east-north-east trending belt formed during the convergence between the Kaapvaal and Congo cratons, resulting in a complex geological and structural environment. The study area is also classified as a hot dessert climate which receives minimal rainfall during the year (average of 88 mm/a). As a result of the low rainfall, there is a low recharge potential to the groundwater aquifers (between 0 – 1%). The two main river systems (Ugab and Omaruru Rivers) that flow through the study area have catchments in the mountainous regions to the east which receive higher rainfall.

Six (6) target areas were identified at desktop level with potential marble and/or alluvial aquifer systems. Within these target areas eight locations were identified as potential geophysical survey areas. These eight locations were prioritised to the three locations which could be surveyed with electromagnetic (EM) and electrical resistivity tomography (resistivity) geophysical survey methods. Three (3) EM and two (2) resistivity lines were surveyed for each of the target areas.

Target 2 is located approximately 27 km northwest of the Uis Tin Mine and represents an alluvial aquifer with the potential to have high yielding boreholes (an existing borehole with an estimate yield of 27 m^3/hr is potentially located near to this target area). The profiles show a 10 – 20 m alluvial (or weathered) layer overlying a more resistive rock (likely to be granite). There are two vertical low resistivity features within the more resistive rock which could represent deeper weathered and/or fracture zones. Two (2) drilling targets were identified targeting the two vertical low resistivity features (one on each profile).

Target 3 is located approximately 37 km northwest of the Uis Tin Mine and is characterised by a potential regional fault which intersects marble unit. There is an alluvial aquifer flowing across this location as well which could assist with recharging the fault and/or marble aquifer. The profiles show an approximately 15 m thick alluvial (or weathered) layer, which is more conductive where the marbles outcrop. The marble has a lower resistivity to the surrounding granitic and felsic pyroclastic rocks and appears to dip towards the north. One (1) drill target was identified targeting the marble unit to the north of the outcrop area and aligning with the regional fault location.

Target 5 is located approximately 55 km northwest of the Uis Tin Mine and is characterised by a potential marble unit with an alluvial aquifer (with a large catchment area) potentially supplying a source of recharge to the marble aquifer. The profiles show a weathered layer with clusters of high resistivity near surface. There is a high resistivity anomaly on both profiles which corresponds to a rock exposure on aerial imagery. Two streams meet and flow around this feature. The profiles show a low resistivity feature to the south and underlying the high resistivity anomaly which could represent the marble unit. Two drilling targets were identified targeting the two low resistivity features (one on each profile).

The details of the eight (8) proposed drill targets are provided in the table below.

The boreholes should be drilled using air-percussion drilling methods. Boreholes should be drilled to a final end-of-hole diameter of 8 inches. Should a borehole intersect yields of greater than 20 m^3/hr, the borehole will need to be reamed to a larger diameter. Screened PVC casing should be installed in all boreholes which intersect a water strike to prevent collapse of the borehole. The annulus of the borehole must be filled with 3 – 5 mm silica sand/gravel until approximately 1 m below surface. A 1 m bentonite seal should be installed at surface to prevent surface contamination from entering the borehole.

After the boreholes have been drilled and constructed, they will need to be aquifer tested to verify the sustainable yield of the borehole. A four (4) hour step test followed by a forty-eight (48) constant discharge test should be performed on all successful boreholes. During the aquifer test, samples should be collected for analysis to determine the groundwater quality.

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Geophysical Target	Drill Target	Longitude	Latitude	Proposed Depth (m)	Priority	Comment
Target 2	ATBH1	498914	7678037	80	High	
Target 2	ATBH2	498616	7677743	80	Low	
Target 2	ATBH3	498907	7677846	80	High	
Target 3	ATBH4	505650	7686133	100	High	This target is projected off the original survey profiles and may need to be resurveyed to confirm the fault location
Target 3	ATBH5	505852	7685532	80	High	
Target 5	ATBH6	518114	7698470	100	High	There were community issues when surveying Target 5. Water supply may be requested if boreholes are drilled here.
Target 5	ATBH7	518258	7698584	100	High	
Target 5	ATBH8	518262	7698716	80	Low	

The following additional recommendations are proposed:

- It is recommended to locate the existing boreholes within the six (6) target areas and if located determine if they can be used by the mine. The boreholes which can be used will need to be aquifer tested to confirm their sustainable yields. Should the existing boreholes all be located, and the estimate yield confirmed the existing boreholes could potentially provide 279 m^3/hr.

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1. Introduction

Digby Wells Environmental (hereinafter Digby Wells) was appointed by AfriTin Mining (Namibia) (Pty) Ltd (hereinafter AfriTin) to undertake a water supply assessment for the planned expansion of production at the Uis Tin Mine, in Namibia.

Currently the pilot processing plant in operation for the Phase 1 Stage I project produces ~65 tonnes of tin concentrate per month. Water demand for the Phase 1 Stage I plant requires ~0.288 Ml/day (12 m^3/hr), which is sourced from the UIS wellfield boreholes, located in the alluvial aquifer of the Uis River. AfriTin has completed a Definitive Feasibility Study (DFS) for the expansion of its Phase 1 Stage I Pilot Processing Facility, which will occur in two phases. The Phase 1 Stage II expansion is a precursor to the long-term Phase 2 expansion, which aims to increase the mining area and develop a full-scale processing plant for the mine.

The expansion of the pilot processing plant for Phase 1 Stage II will increase production to ~100 tonnes of tin concentrate per month, which will increase the water demand of the plant to ~0.432 Ml/day (18 m^3/hr). The Phase 2 expansion plans to increase production to ~1 250 tonnes of tin concentrate per month. The water demand for the Phase 2 expansion still needs to be confirmed.

The aim of the water supply assessment is to:

- Verify the potential supply constraints of the Uis wellfield for the planned Phase 1 Stage II expansion; and
- Investigate the regional aquifer systems as an additional source of groundwater for the Phase 2 expansion.

A parallel investigation is confirming if the ten (10) boreholes AfriTin currently have near to the mine, could potentially cover the Phase 1 (Stage I and II) water requirements. The focus of this report, therefore, is on locating potential drilling targets within the regional aquifers surrounding the mine to provide an additional source of groundwater for the Phase 2 expansion and/or supplement the Phase 1 (Stage II) expansion requirements should the current boreholes be insufficient for this requirement.

2. Baseline Conditions

2.1. Climate

The study area is classified as a hot desert climate (BWh) based on the Köppen-Geiger classification system. The BWh classification characterises areas where evaporation and transpiration exceed precipitation with hot to exceptionally hot (over 40°C) periods of the year.

Annual rainfall data was collected from four weather stations around the project area, which were measured daily between 1979 and 2014. The rainfall data is relatively consistent between the weather stations. Rainfall typically occurs between October and April, with the months of February and March receiving the highest rainfall (Figure 2-1). The annual rainfall for the project area ranges between ~2 - 592 mm, with an average of 88 mm per year (National Centers for Environmental Prediction, 2022) (Environmental Compliance Consultancy, 2021).

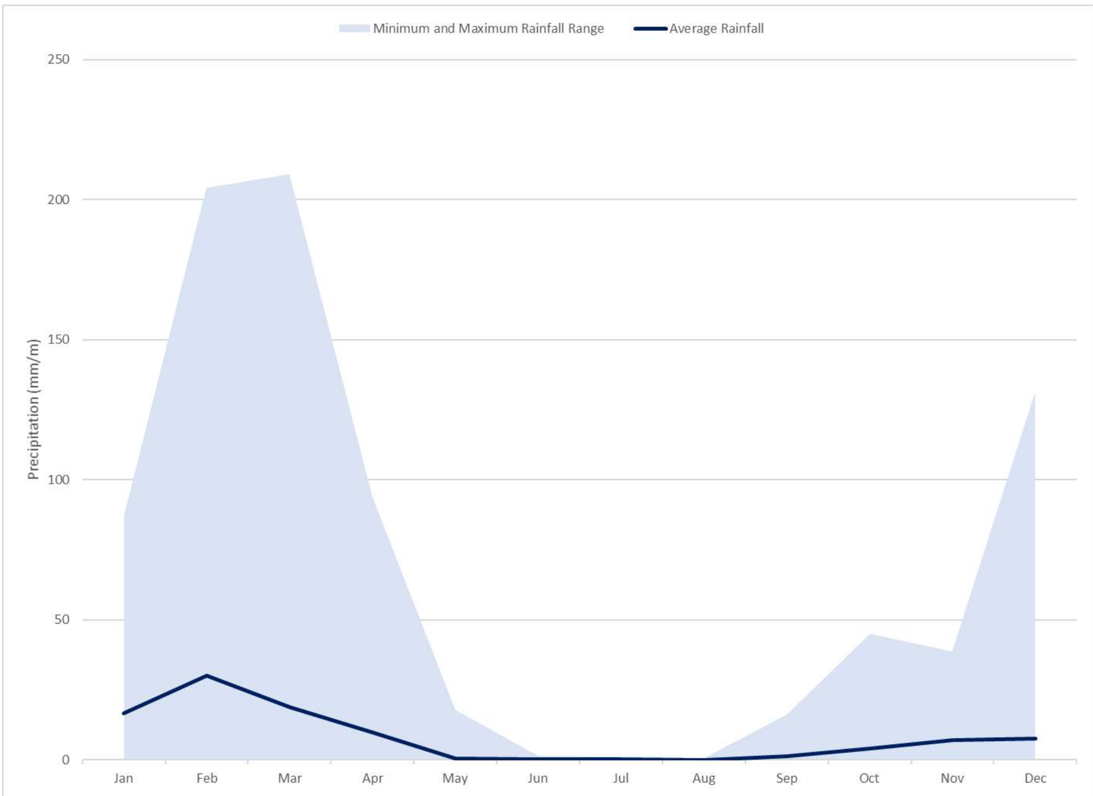

Figure 2-1: Monthly Rainfall

2.2. Recharge

The NA-MIS (Namibian Monitoring Information System) and hydrogeological map of Namibia indicates that the area has an effective groundwater recharge percentage of between 0 – 1% (Figure 2-2) of the average annual recharge (Groundwater Management Institute, 2022). The highest recharge potential occurs in Target Area D.

Although Target Area C, E and F are located in the area which indicates 0% recharge, a chloride mass balance calculation using a rainwater sample collected on 19 January 2022 indicates that the boreholes near Uis do receive approximately 0.7% recharge. This would indicate a maximum contribution percentage as the equation does not account for surface water runoff or the presence of chloride in the environment (i.e., gypsum) which may influence the chloride concentration recharging to or occurring within the aquifer. The following equation was used to calculate the recharge to the aquifer using chloride as a tracer:

$$R = P.\frac{Clp}{Clgw}$$

Where R is the groundwater recharge flux, P is the average annual precipitation, Cl_p is the average chloride concentration for precipitation and Cl_{gw} is the average chloride concentration for groundwater.

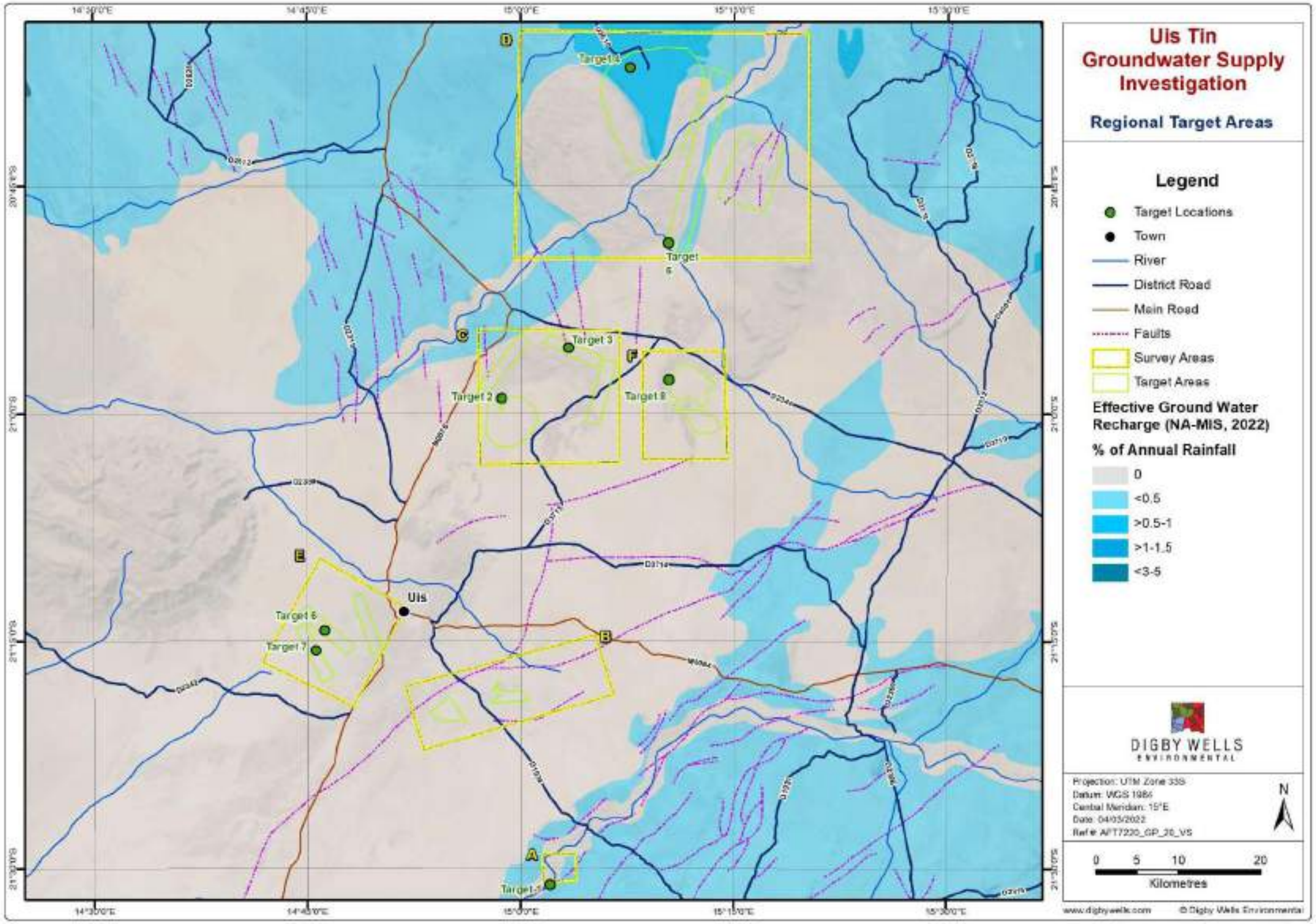

Figure 2-2: Recharge

2.3. Topography and Drainage

The town of Uis is located within the Uis River which is a tributary within the Ugab Catchment Area. The Uis River drains the project area in a north-westerly direction until it joins the Ugab River. The Ugab River is the main river that drains the Ugab Catchment which has an area of ~29 000 m^2. The Ugab Catchment starts in a mountainous region which receives a higher annual rainfall of between ~500 - 550 mm.

Although the town of Uis is located in the Ugab Catchment Area, the town receives water from the Omaruru River. The Omaruru River drains the Omaruru Catchment which has an area of ~11 500 m^2 and receives an annual rainfall of between ~300 - 350 mm from the mountainous region upstream.

3. Regional Survey Targets

A desktop level assessment (AfriTin Mining, 2021) identified six (6) regional target areas that could potentially supply groundwater for the Uis Tin Mine. The six (6) target areas were identified based on the available geological and catchment information (Figure 3-1).

The 1:250 000 geological map of the region indicates that the regional targets are distributed between the Zerrissene and Swakop Groups of the Damara Sequence (Ministry of Mines and Energy. Geological Survey of Namibia, 2006) (Ministry of Mines and Energy. Geological Survey of Namibia and Finland, 1997). The Damara Orogen is an East-North-East trending belt formed during the convergence between the Congo and Kalahari Cratons. The belt comprises of multiple fault and shear bounded zones with varying structural styles and lithologies (Gray, et al., 2008). A summary of the main stratigraphy for each of the Target Areas is provided in Table 3-1. A brief description of the geology is provided for each of the Target Areas under the respective subsections.

Table 3-1: Regional Stratigraphy

Supergroup	Group	Formation	Lithology	Map Code	Target
Quaternary			Undifferentiated sediments	Qs	B, C, E, F
			Gravel	Qg	D
Damara Granites			Granite (fine-medium grained, monzogranite)	OgSsp	C
			Granite (fine-medium grained)	ϵggp	E
			Granite (coarse grained, porphyritic)	NgSAs	C, D, F
			Granite (medium-coarse grained, porphyritic)	NgSAp	C
Damara Sequence	Swakop	Kuiseb	Mica schist and shale	NKs	A, B, D
	Swakop	Karibib	Marbles	NKb	A, B, D
	Zerrissene[1]	Amis	Meta-greywacke and meta-pelites	NAm	E
	Swakop	Okatjise	Dolomite	NOz	C, D
	Nosib	Naauwpoort (Summas Member)	Felsic pyroclastic rocks	NNpSm	C, D

[1] Zerrissene Group is mapped as part of the Southern Kaoko Zone whilst the Swakop Group is mapped as part of the Swakop (Central) Zone. The Amis Formation metamorphic events occurred at a similar time to the Karibib Formation metamorphism.

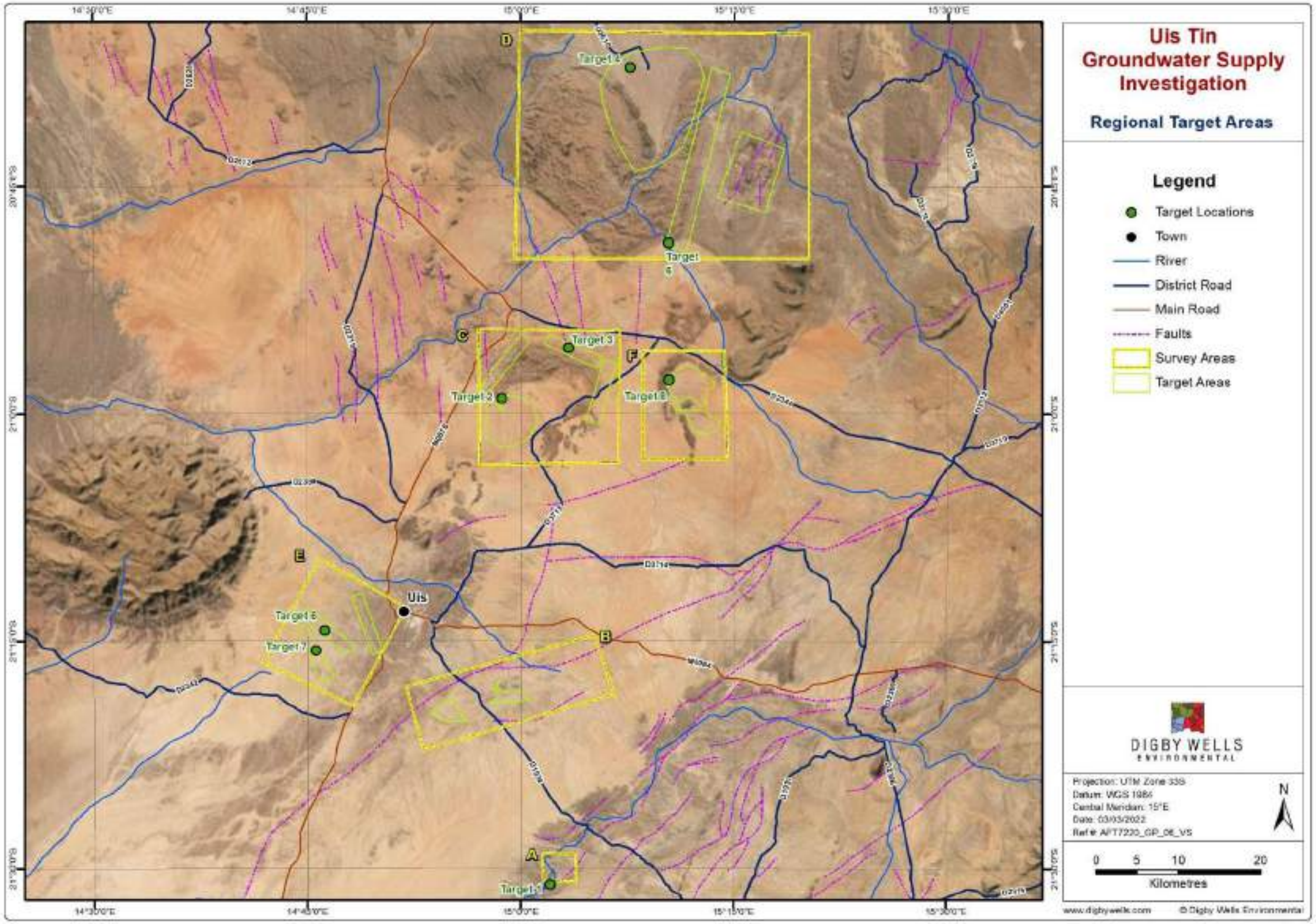

Figure 3-1: Regional Targets

3.1. Target Areas

3.1.1. Target Area A

Target Area A is located on the Omaruru River system, which has a large catchment area upstream of the target area (Figure 3-2). Borehole targets could be positioned within the water course area, without a geophysical survey, to assess the potential of this alluvial aquifer.

Target Area A also has an outcrop of marble which has been significantly folded, occurring as a synclinal fold on the limb of a larger anticlinal fold structure. This marble may be recharged by the Omaruru River which intersects the marble on the western side. The continuity of the marble underneath the younger mica schist (east of this area) is unknown but based on the geological cross-section (provided with the 1:250 000 map) indicates that there may not be a connection to the marbles east of Target A, as the marbles to the east are associated with a synclinal feature.

There is some faulting in this area which is predominantly northeast-southwest orientated, parallel to the Omaruru River. This marble lithology is likely to be isolated with limited recharge potential, and therefore the alluvial aquifer of the Omaruru River system may be the best water source option within this Target Area.

No boreholes have been previously identified in this Target Area, so potential borehole yields are unknown. However, there is a water scheme within this Target Area that provides fresh water to Uis.

Target 1 has been positioned just south of the Target Area A and is considered an intermediate priority target (for a geophysical survey). The borehole could be positioned in the Omaruru River without a geophysical survey however a geophysical survey could assist with identifying the fault at the marble schist contact.

3.1.2. Target Area B

Target Area B is located on a water divide between the Omaruru and Ugab River systems, in an area which likely receives little recharge from rainfall (~50-150 mm per year). The alluvial aquifers in this Target Area have a relatively small catchment area from which recharge can be collected, which will reduce the sustainability of water supply from this Target Area (Figure 3-3). This target area would need to focus on intersecting fractures.

Target Area B is also associated with an outcrop of a marble lithological unit as part of an anticlinal fold surrounded by mica schist. There may be continuity between the marble unit in Target Area B and the marble unit to the southeast may be possible via a synclinal feature underlying the mica schist, however both these areas are on the water divide with limited recharge potential. Secondary porosity features would need to be connected at depth between these two marble units, as the mapped faulting in the mica schist occurs in a northeast southwest orientation (parallel to the marble outcrop areas).

No boreholes have been previously identified in this Target Area, so an estimated yield is unknown. No priority areas have been identified in this Target Area.

3.1.3. Target Area C

Target Area C is located around an anticlinal feature with a thin marble unit surrounding a core of pyroclastic rocks (Figure 3-4). The target areas proposed for this area focus on the marble unit and an alluvial aquifer. The alluvial aquifer has one drainage point which could potentially allow for the storage of groundwater as flow may potentially be obstructed by the pyroclastic rocks. Boreholes were identified in the alluvial aquifer which indicated yields of between 0.4 l/s and 7.7l/s. Two geophysical survey priority areas have been identified in this Target Area.

Target 2 is located in the alluvial aquifer to try and characterise the deeper flow channel. The catchment area for this alluvial aquifer may be relatively small, but there are potentially high yielding boreholes from this system. It is also recommended to locate, and aquifer test the highest yielding borehole in this area. Target 2 has been identified as a high priority area for the geophysical survey.

Target 3 is located on a fault structure which intersects the marble unit. There is a drainage system which flows through this feature which would provide an additional source of water from the alluvial catchment area. Target 3 has been identified as a high priority area for the geophysical survey.

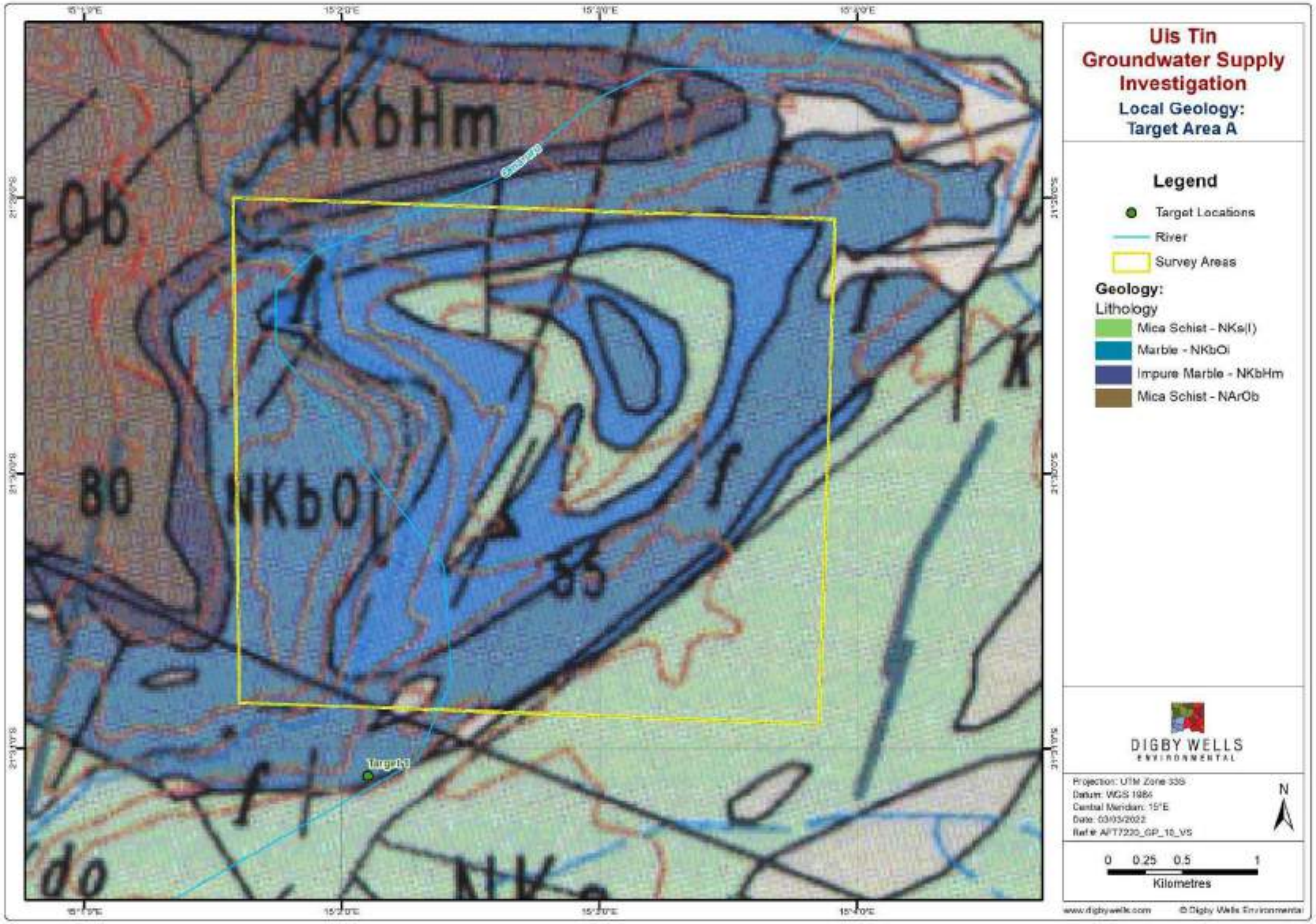

Figure 3-2: Target Area A

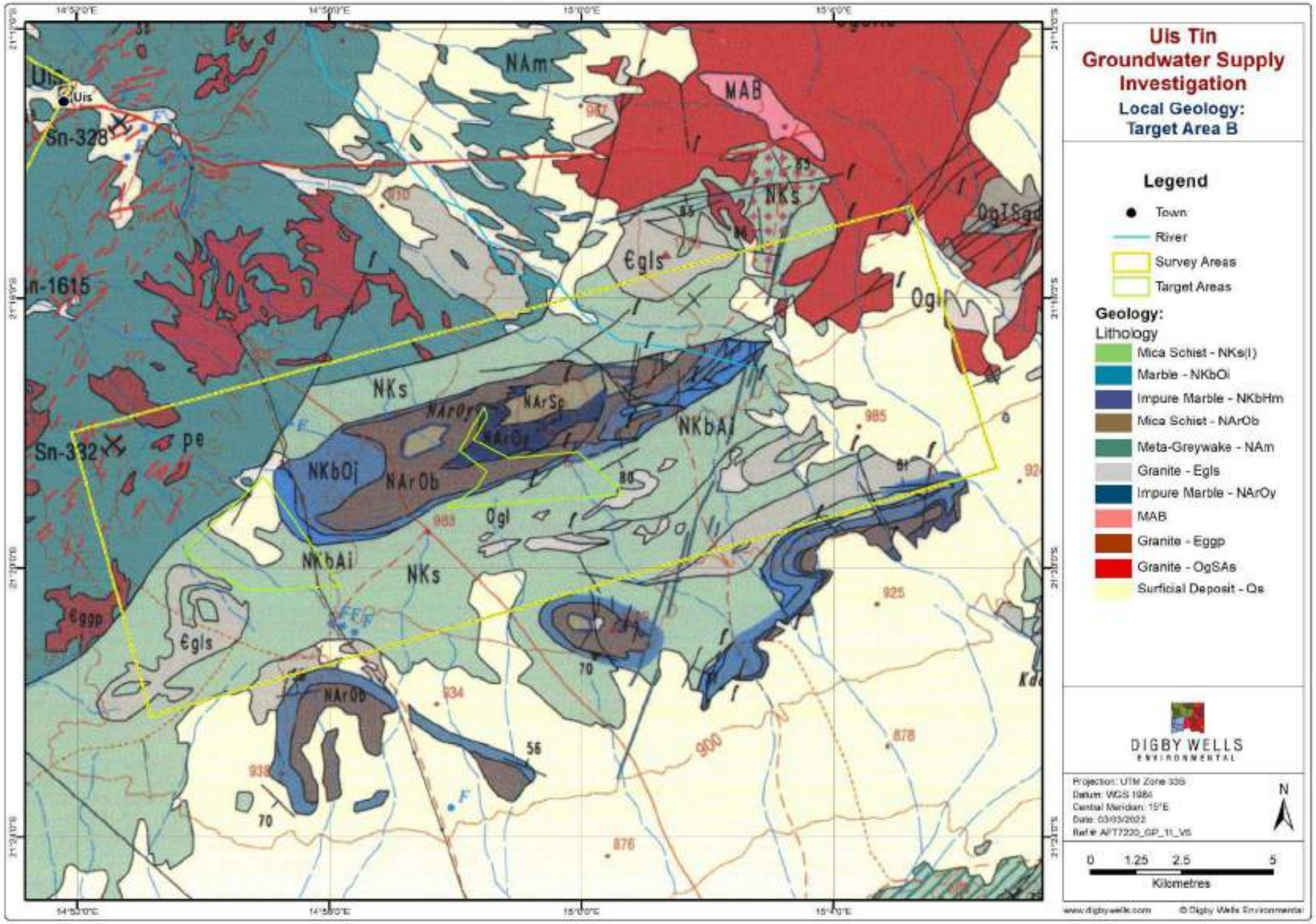

Figure 3-3: Target Area B

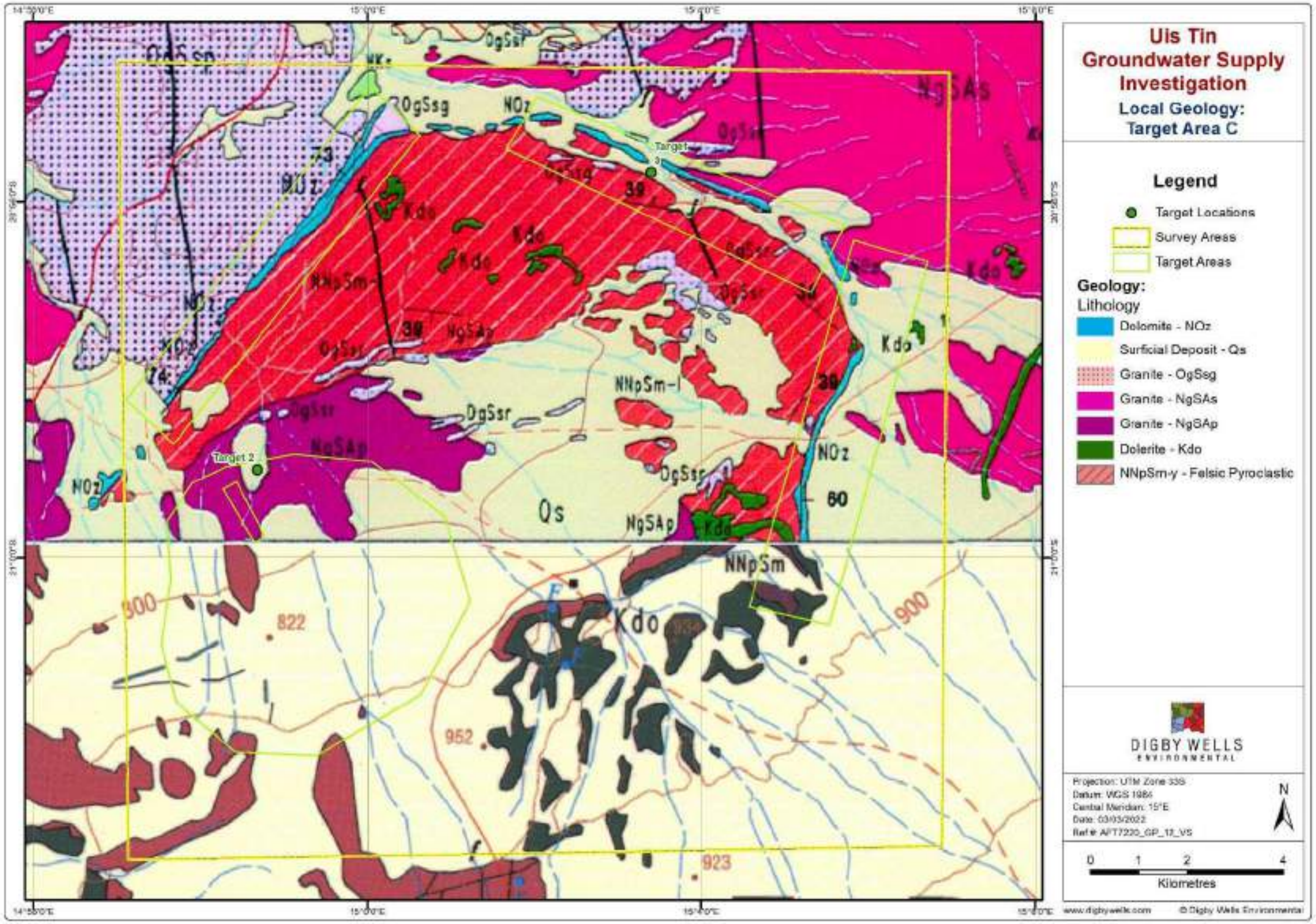

Figure 3-4: Target Area C

3.1.4. Target Area D

Target Area D is a large area located on and in close proximity to the Ugab River system (Figure 3-5). Boreholes have been identified in this Target Area with yields that range between 1.1 l/s and 23.9 l/s. The highest yielding boreholes are in an alluvial sedimentary layer which terminates in a fold structure comprising of marble and pyroclastic rocks. It is recommended to locate the two existing, high yielding boreholes and aquifer test them to confirm their sustainable yields.

Should these boreholes not be located, then this area could be investigated further using the ground geophysical survey methods. The alluvial area is identified as Target 4. However, it is considered an intermediate priority target for the geophysical survey based on the presence of existing boreholes which can be tested, and the significant distance between this area and the mine.

Another potential priority area (Target 5) within Target Area D is located on the southern end of subsection a. This section has a linear marble unit which intersects the Ugab River as a potential recharge source for any underlying secondary porosity features. The marble unit potentially extends underneath an alluvial aquifer which has a large catchment area for potential recharge to the southeast of this location in addition to the above-mentioned marble unit. Target 5 is therefore considered a high priority target.

3.1.5. Target Area E

Target Area E is located on tributaries of the Ugab River system (Figure 3-6). A dyke feature may cross these tributaries downstream of the proposed target areas which may assist with storage of groundwater in the alluvial aquifers upgradient of the dyke. There are no mapped faults in this area.

The mine has drilled boreholes upstream of the eastern-most tributary (tributary closest to the mine) which are scheduled to be aquifer tested as part of Phase 1 of the water supply investigation to determine their sustainable yields. Utilising these boreholes will likely reduce water flow to the downstream target area, indicating that the eastern-most target in Target Area E may be unsustainable as a long-term source.

The two other targets in Target Area E are associated with different tributaries. Boreholes with an estimated yield of between 1.4 l/s and 3.4 l/s have been identified in these tributaries. It is recommended that these boreholes be located, as alternative water supply boreholes, which can be aquifer tested to confirm the sustainable yield. Should the boreholes not be located, new boreholes could be installed within the tributary alluvials without a geophysical survey.

Target 6 and 7 have been identified in this Target Area but are considered low priority targets for a geophysical survey, as boreholes can be positioned in the tributary footprint without a geophysical survey and there are existing boreholes which could be tested.

3.1.6. Target Area F

Target Area F is located within a half ring dyke structure where the alluvial aquifer only has one exit point for a tributary of the Ugab River system (Figure 3-7). The alluvial catchment area within this ring structure is relatively small indicating the sustainability of this source may be limited. One low yielding borehole (0.3 l/s) has been identified in this Target Area. Two other boreholes have been identified in this Target Area, but the yields for these boreholes are unknown. It is recommended to locate these boreholes and aquifer test them if possible.

A geophysical survey target (Target 8) has been identified in this area. However, it is considered a low priority target for the geophysical survey based on the presence of existing boreholes that could be tested. It should be noted that if this target would be developed as a water supply, it could potentially reduce the yield from the alluvial aquifer at the downgradient Target 3.

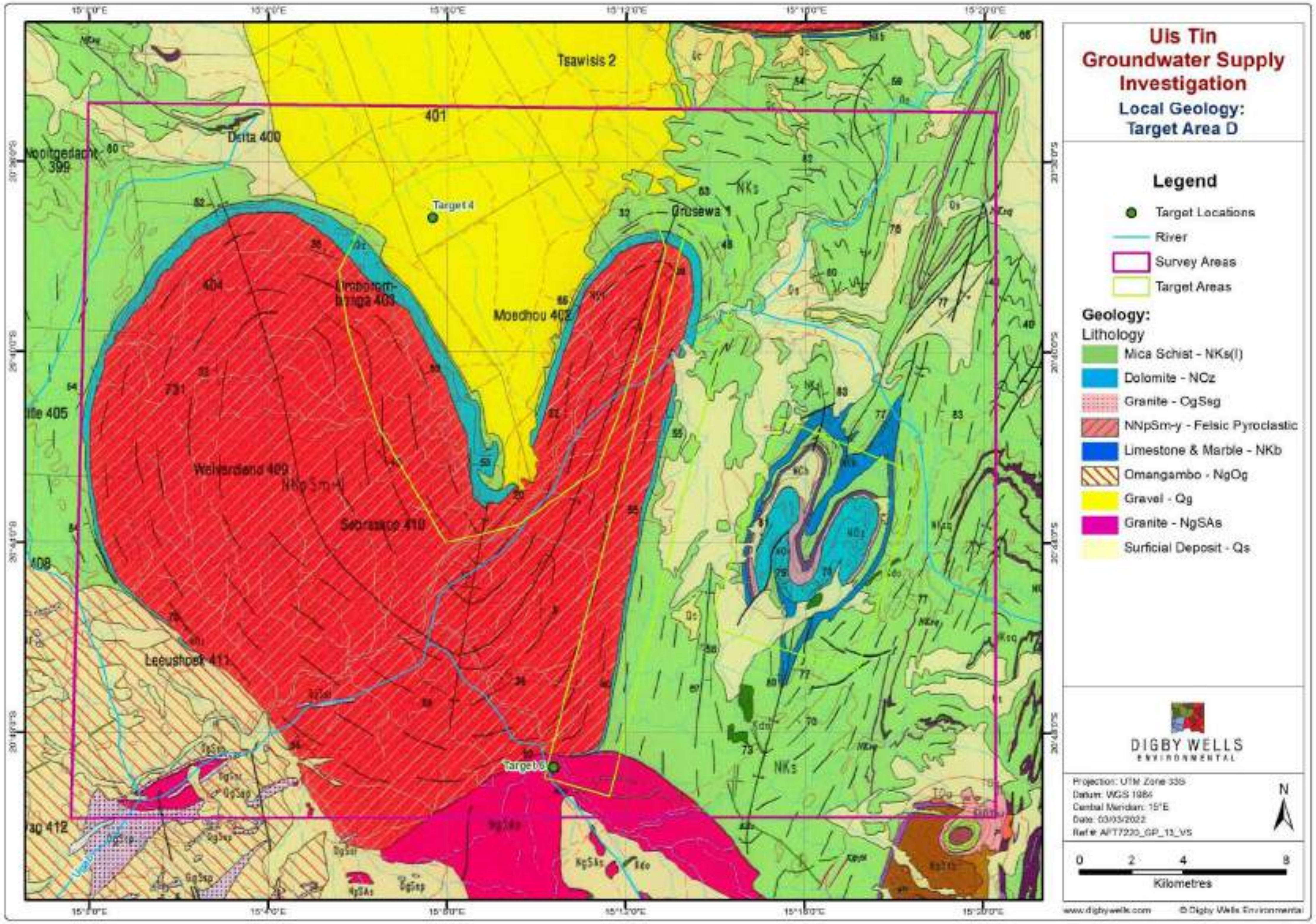

Figure 3-5: Target Area D

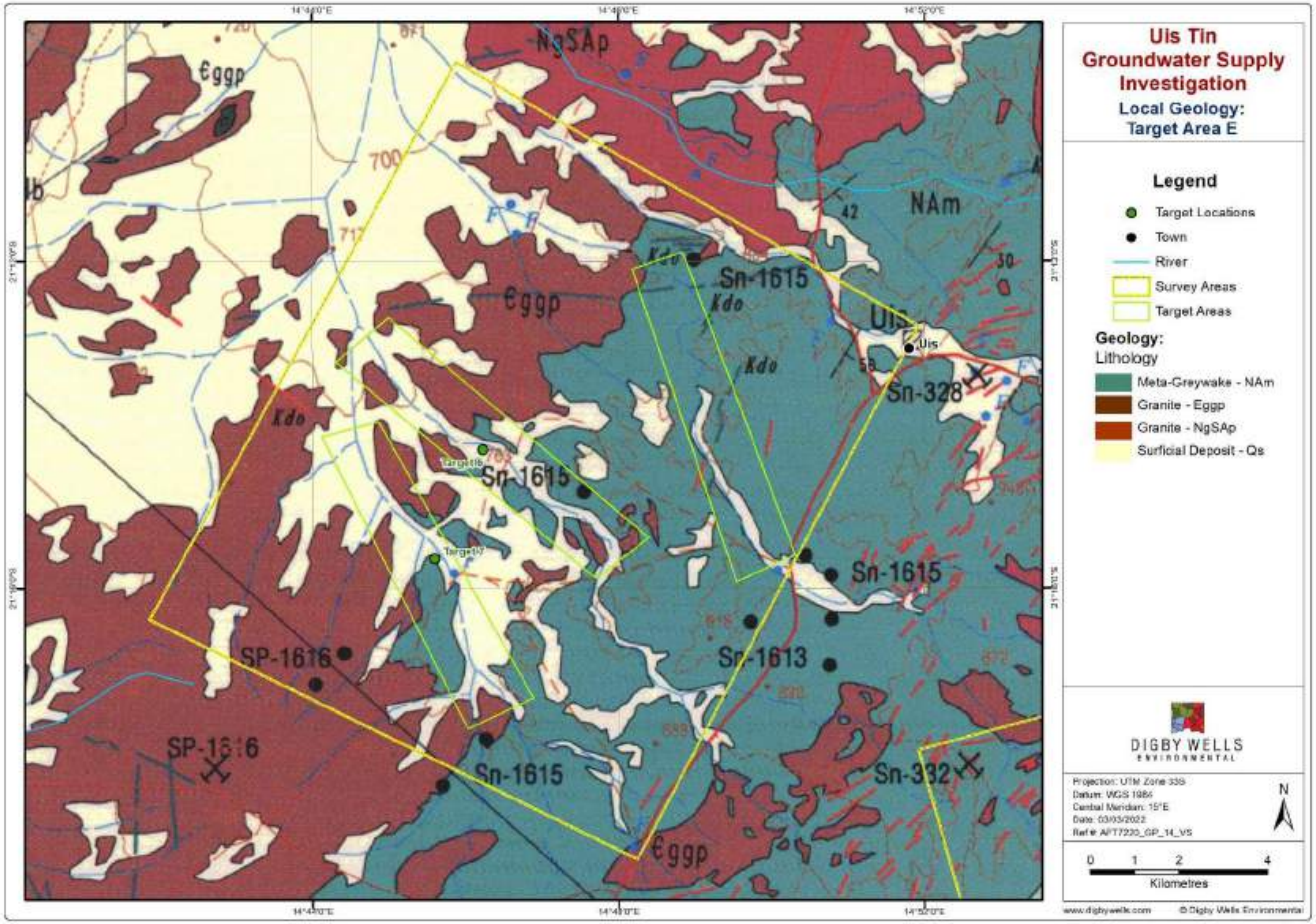

Figure 3-6: Target Area E

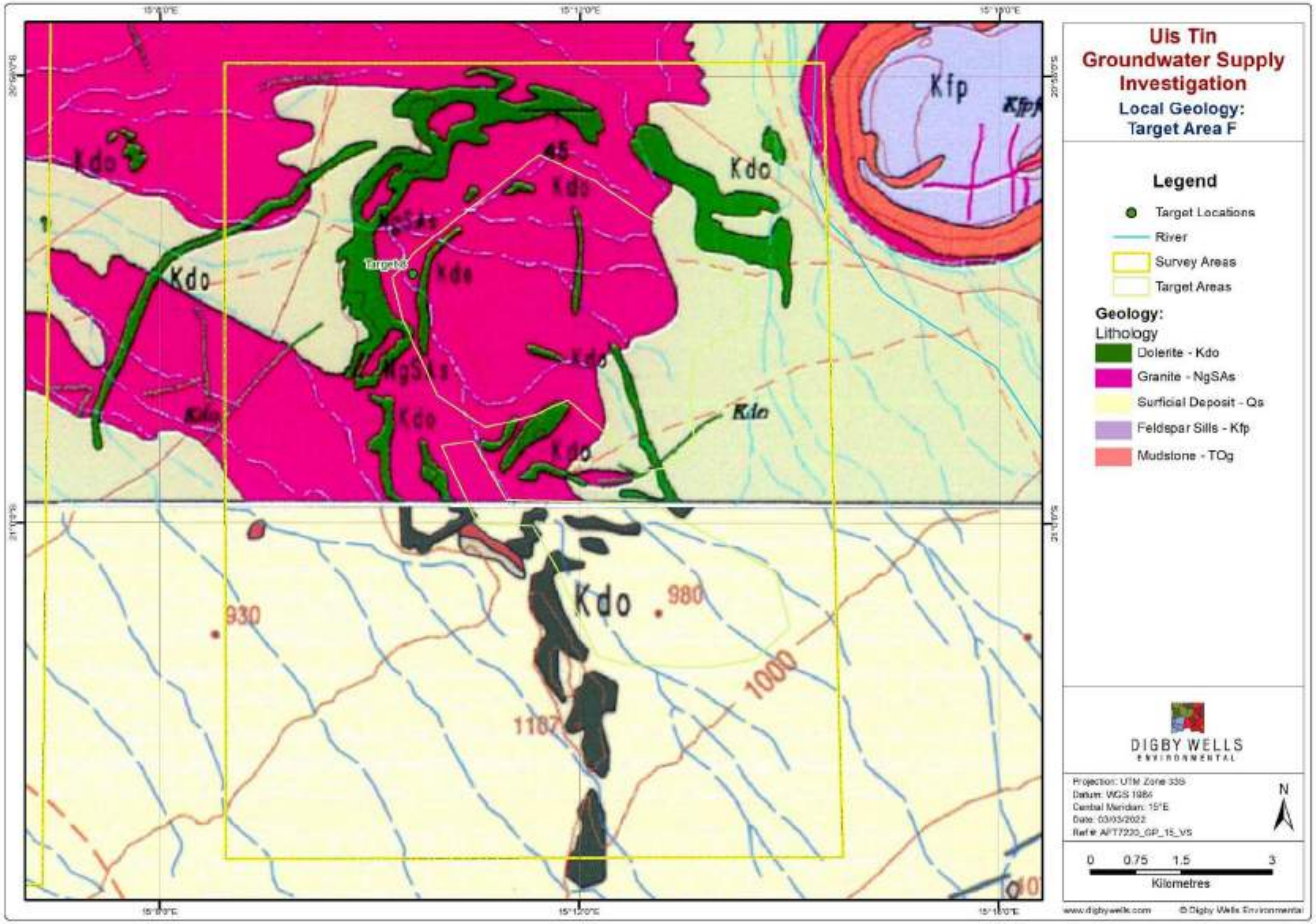

Figure 3-7: Target Area F

3.2. Priority Target Locations for Geophysical Surveys

Based on the review of the available information, a total of eight priority areas have been identified for the geophysical survey within the six proposed Target Areas. These are summarized in Table 3-2 below and prioritized to the three (3) highest priority areas.

It is recommended to try and locate the identified boreholes in Target Areas C, D, E and F and if possible, test these boreholes to confirm a sustainable yield from an already existing borehole. If these boreholes no longer exist, a geophysical survey could be undertaken to intersect the same feature and potentially try duplicate the estimated yields from these areas.

Table 3-2: Summary of Priority Targets for the Geophysical Survey

Target ID	Priority	Reason
3	High	Marble unit, intersected by a fault with a drainage line associated with an alluvial catchment area.
5	High	Marble unit potentially recharged by the Ugab River, and a drainage line associated with an alluvial catchment area.
2	High	In a potentially high yielding alluvial aquifer, recommend locating and test existing high yielding borehole. Located closer to the mine so given a higher priority.
4	Intermediate	In a potentially high yielding alluvial aquifer, recommend locating and test existing high yielding boreholes first.
1	Intermediate	In a the Omaruru River which has a large catchment area, geophysics could be used to target the fault at the marble schist contact
8	Low	In a ring structure with a relatively small catchment area for the alluvial aquifer.
6	Low	In a tributary channel for the Ugab River, catchment area limited by water divide, could potentially site boreholes without geophysics.
7	Low	In a tributary channel for the Ugab River, catchment area limited by water divide, could potentially site boreholes without geophysics.

4. Study Limitations

The following limitations are applicable to this assessment:

- The 2D resistivity survey can only be conducted in areas where there is sedimentary cover into which the stainless-steel pegs can be inserted. This survey method is therefore limited to the alluvial aquifer systems as well as aquifer systems which may underly the alluvial aquifers; and
- Target areas have identified marble lithological units as potential targets. Marbles are a metamorphosed carbonate rocks which have the potential to be water bearing but only via secondary porosity features (fractures and cavities). For a sustainable water supply from marbles, the secondary porosity features would need to be interconnected and linked to a recharge area and have a sufficient aquifer extent to be able to sustainably yield sufficient volumes of groundwater.

5. Survey Results

The three high priority targets (Table 3-2) were assessed using electromagnetic (EM) and electrical resistivity tomography (resistivity) geophysical survey methods. The EM method was surveyed first to identify any high conductive targets which could be assessed better with the resistivity method afterwards. The methodology is provided in Appendix A and the individual profiles are provided in Appendix B.

5.1. Target 2

Target 2 is located approximately 27 km northwest of the Uis Tin Mine. This target area is characterised by a sedimentary cover which is drained in a north-westerly direction by a tributary to the Ugab River. The catchment area converges against an outcrop of granite. Although the catchment area of the stream is relatively small and located within a low recharge zone of the study area, there is an existing borehole located in this catchment that has an estimated yield of 27 m^3/hr (AfriTin Mining, 2021).

The survey area was selected to assess the alluvial sediments within the river channel upstream of the granite outcrop. This existing borehole is located approximately 1 km east of the surveyed area.

Three (3) EM survey lines and two (2) resistivity lines were walked for this target (Table 5-1 and Figure 5-1).

Table 5-1: Target 2 Survey Lines

Method	Label	Start		End		Length (m)	Direction
		Longitude	Latitude	Longitude	Latitude		
EM	Line 1	499051	7678216	498340	7677802	800	NE-SW
	Line 2	499129	7678121	498371	7677798	820	NE-SW
	Line 3	499169	7677995	498451	7677670	800	NE-SW
Res	Line 3	499156	7677923	498181	7677598	1 000	NE-SW
	Line 5	498993	7678064	498410	7677864	600	NE-SW

The contoured EM results indicate a range of conductivities between -13 – 16 mS/m, with the higher values representing rocks which are more conductive. The EM results (Figure 5-2) identified a high conductive feature on the western area of the contoured area. This area is characterised by sediments with more of an orange colour. The resistivity lines were planned to survey across this feature.

The resistivity profiles are shown with a range of resistivity of between 0.6 – 14 786 ohm.m (Figure 5-3). Values in the range of 0.6 – 47 ohm.m are represented in shades of blue and indicate rocks with more conductive properties. Values in the range of 829 – 14 786 ohm.m are represented by shades of orange, red and purple and indicate rocks with more resistive properties.

The profiles show that there is a 10 – 20 m layer at the top of both profiles with a lower resistivity range of between 11 – 196 ohm.m. This layer is likely to be representative of the alluvial cover. Underlying this alluvial cover is a more resistive rocks with a range of between 829 – 14 786 ohm.m which is likely to be granite based on the 1:250 000 geological map. Fresh unweathered igneous and metamorphic rocks typically have a range in resistivity of between 1 000 – 100 000 ohm.m (GeoSci Developers, 2022). Within the higher resistivity rock there are two vertical zones which have a lower resistivity in the range of 47 – 829 ohm.m on Line 3.

The low resistive feature between stations 160 – 320 aligns with a defined stream channel on the aerial imagery. This feature could be associated with deeper weathering along the stream and/or a fractured zone within the higher resistivity "granite" rock. This feature is identified on Line 5, between stations 50 – 110. A drilling target (Table 6-1) is proposed on this feature on the Line 5 profile as the resistivity values on Line 5 are slight lower than Line 3 (although they fall in the same 47 – 829 ohm.m range).

The low resistive feature between stations 540 – 650 corresponds to the high conductivity feature identified in the EM results. This feature has a slightly higher resistive base (of 829 ohm.m) at a depth of approximately 30 m indicating that this feature could be associated with deeper weathering. The profile for Line 5 indicates that the 829 ohm.m resistivities are slightly shallower at between 10 – 20 m depth with the Line 3 feature possibly extending to Line 5 between stations 240 – 290 or after station 510. This feature has a higher resistivity at depth and is therefore less likely to have water compared to the first feature. A secondary drill target (Table 6-1) is proposed here but is assigned a lower priority.

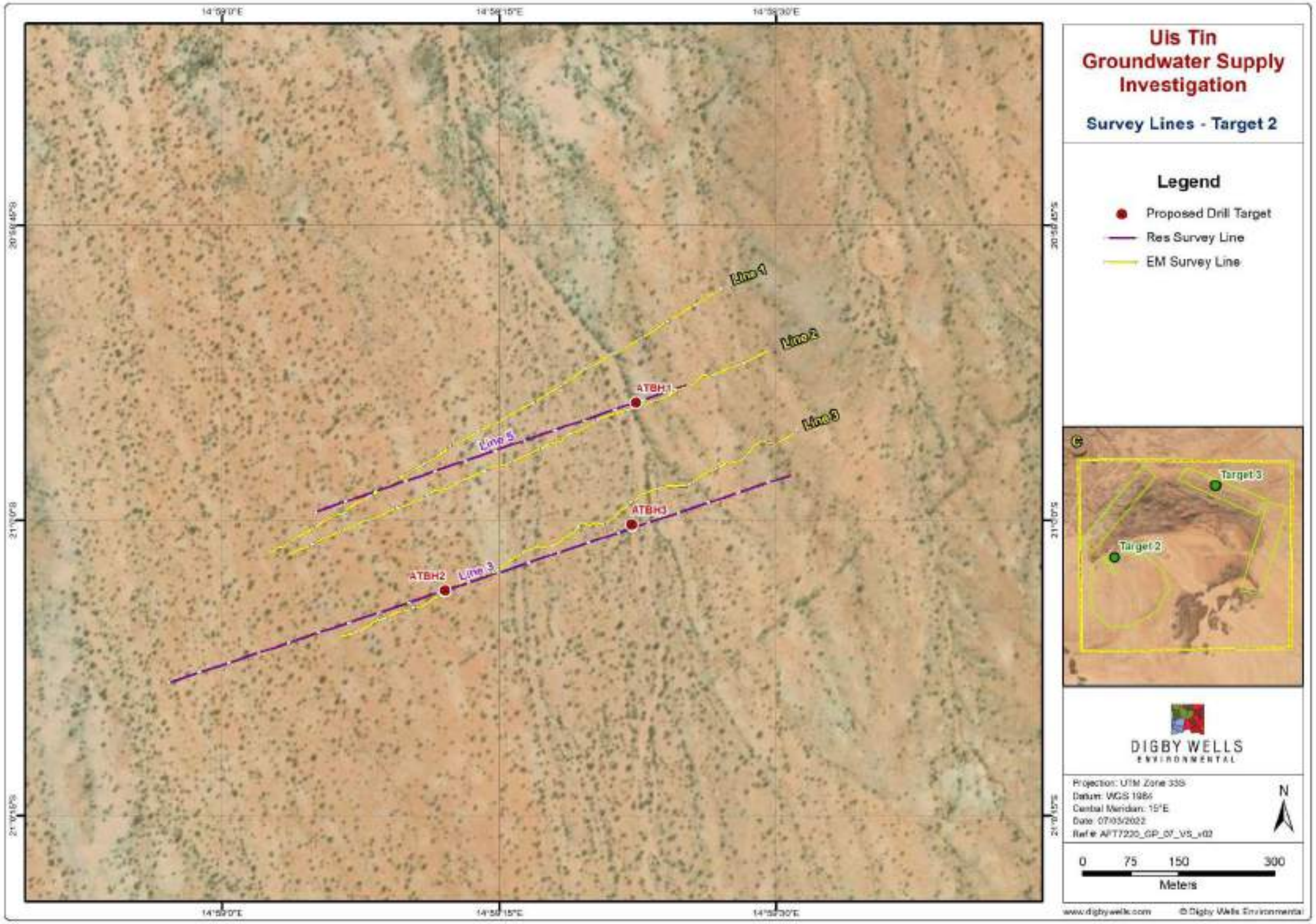

Figure 5-1: Target 2 Survey Lines

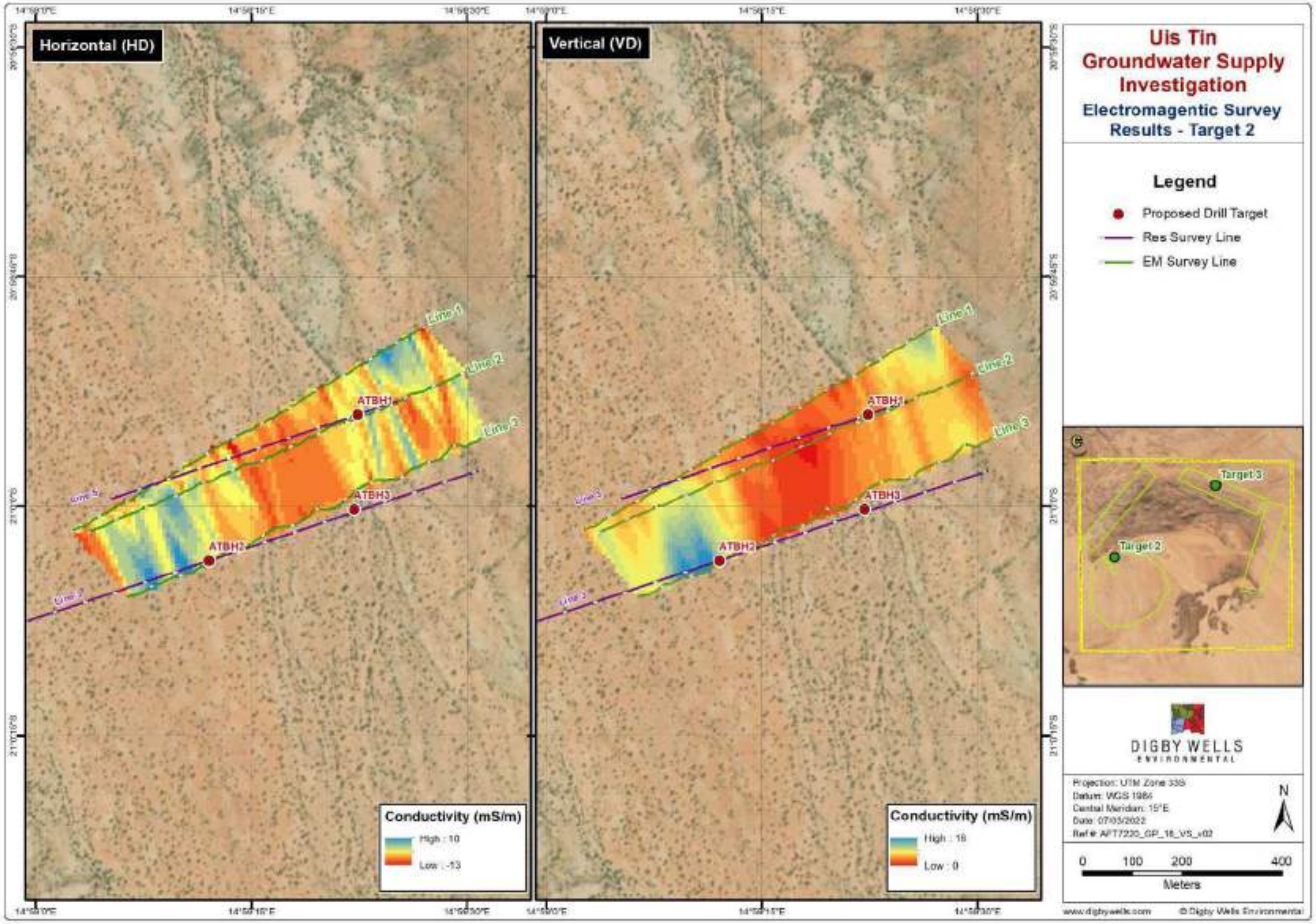

Figure 5-2: Target 2 Contoured EM Results

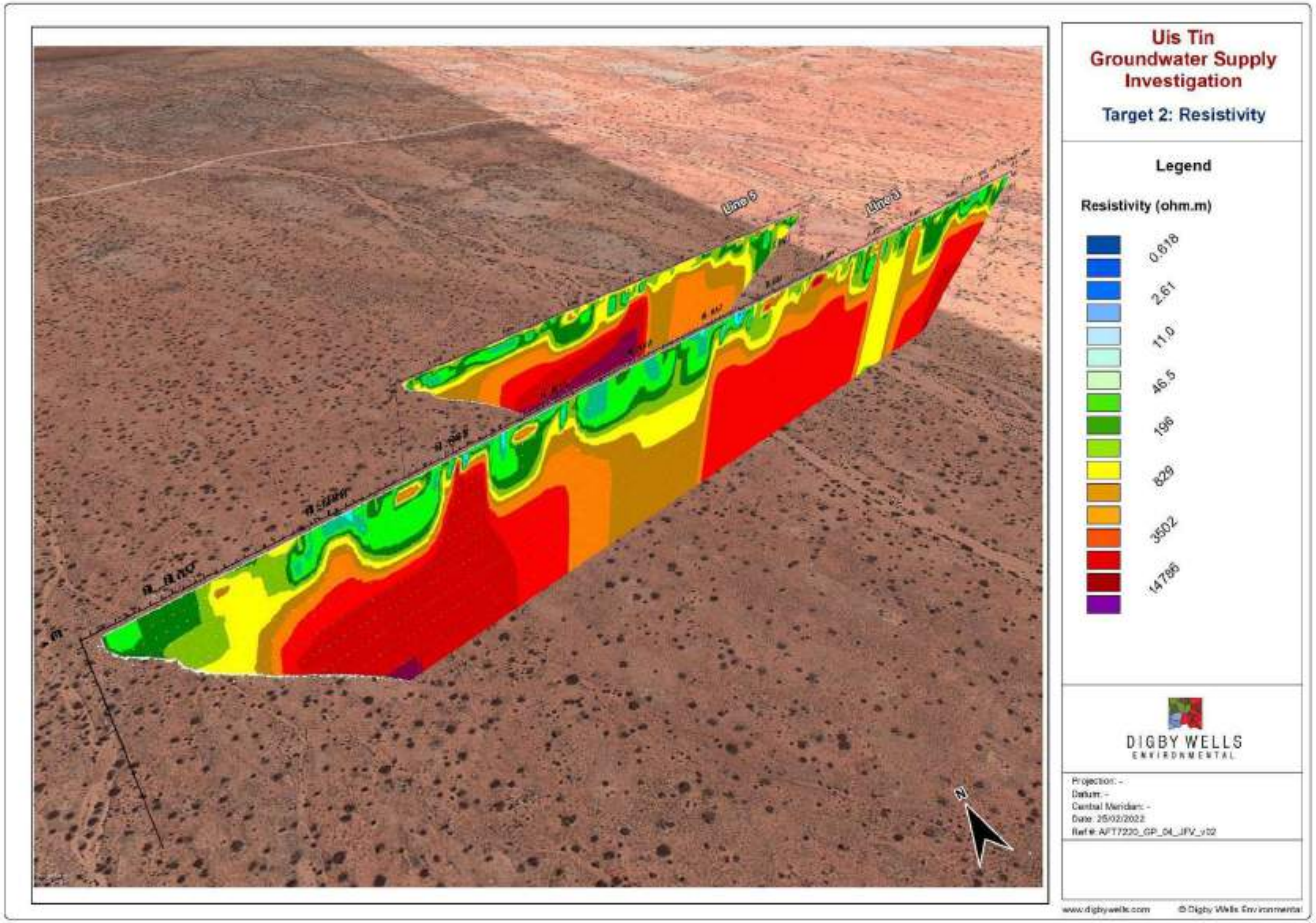

Figure 5-3: Target 2 Resistivity Profiles

5.2. Target 3

Target 3 is located approximately 37 km northwest of the Uis Tin Mine. This target is characterised by a marble unit which is potentially intersected by a regional northwest-southeast trending fault (which could potentially extend to the Ugab River). An alluvial aquifer is also present in this area which drains the catchment area in a north-westerly direction along the marble unit and across the fault structure which could assist with recharging the fractured aquifer. The catchment area is larger than that of Target 2, but it is still located within the low recharge zone. Should the regional fault be connected to the Ugab River system however this target could receive a more sustainable source of recharge.

Three (3) EM survey lines and two (2) resistivity lines were walked for this target (Table 5-2 and Figure 5-4).

Table 5-2: Target 3 Survey Lines

Method	Label	Start		End		Length (m)	Direction
		Longitude	Latitude	Longitude	Latitude		
EM	Line 1	505380	7685624	506123	7685907	800	SW-NE
	Line 2	505457	7685509	506191	7685818	800	SW-NE
	Line 3	505559	7685406	506298	7685700	800	SW-NE
Res	Line 1	505557	7685410	506291	7685741	800	SW-NE
	Line 2	505498	7685948	506203	7685218	1 100	NW-SE

The contoured EM results indicate a range of conductivities between 1 – 74 mS/m, with the higher values representing rocks which are more conductive. The EM results (Figure 5-5) identified a high conductive feature in the regional fault across the marble unit of the contoured area. The resistivity lines were planned to survey across this feature.

The resistivity profiles are shown with the same resistivity range as Target 2 (0.6 – 14 786 ohm.m) (Figure 5-6).

The profiles show that there is a layer approximately 15 m thick at the top of both profiles with a lower resistivity range of between 0.6 – 47 ohm.m. The lower resistivity values in this layer correspond to the location of the marble unit. Underlying this layer are more resistive rocks with a resistivity in the range of 3 502 ohm.m.

Profile 1 was surveyed perpendicularly across the fault and marble and shows a lower resistive feature between stations 290 – 560 which corresponds to where the marble unit is on the profile and the likely position of the fault. The high resistive rocks on either side of this feature corresponds to granite and felsic pyroclastic lithologies on the 1:250 000 geological map.

Profile 2 was surveyed across the fault and along the marble. This profile shows a low resistive feature between station 0 – 210 which would correspond to the northern contact of the marble with the granite rock. Dip direction in the felsic pyroclastic rocks near Target 5 indicate that there is a dip towards the north in this area. If the marble follows the same dip this would indicate that the marbles would be dipping towards the low resistive feature in Profile 2 and that the high resistive feature between station 210 – 1 100 would be influenced by the felsic pyroclastic rocks beneath the surface exposure of the marble. A drill target (Table 6-1) is proposed to intersect the fault within the marble unit (north of the surface exposure of the marble).

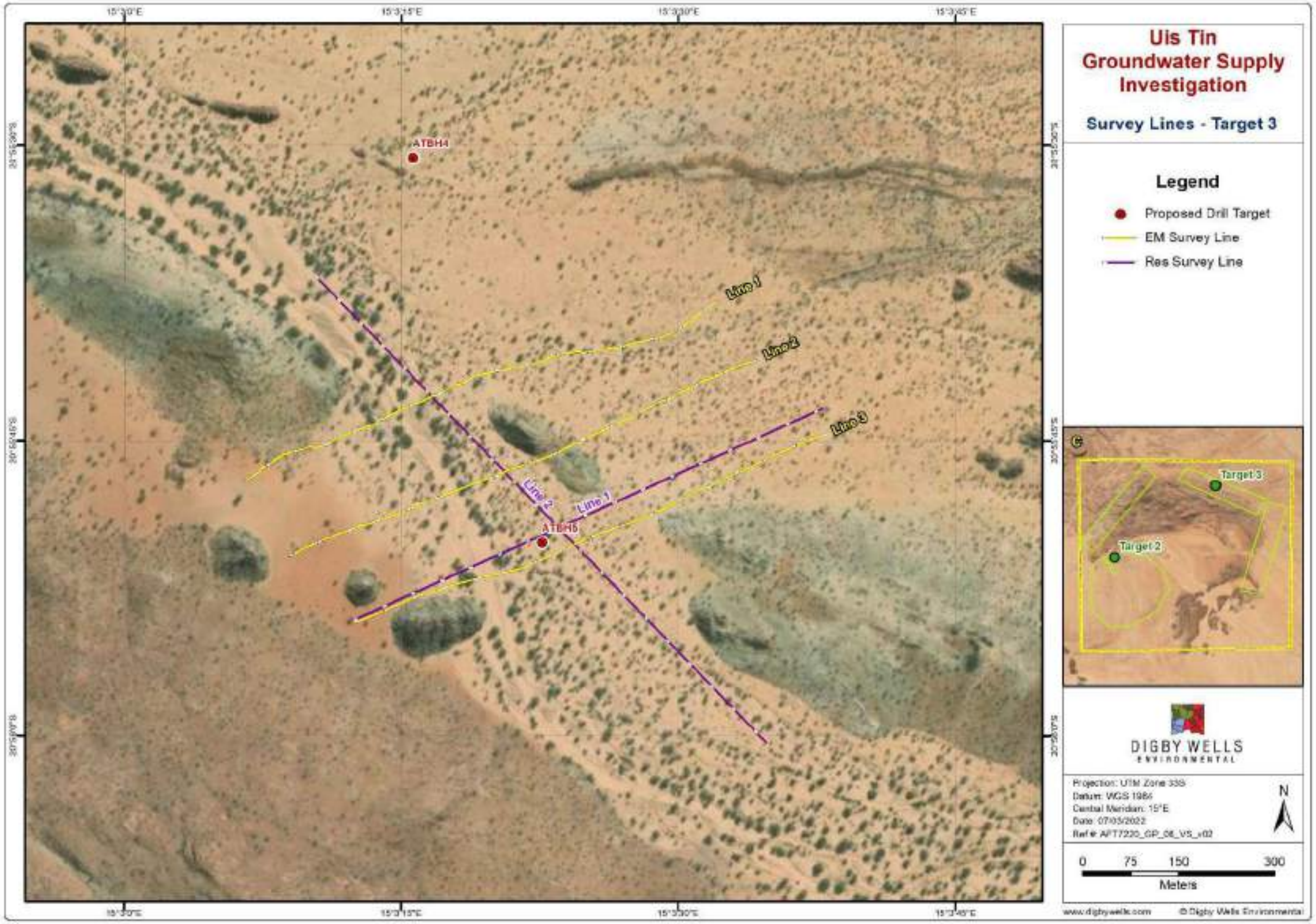

Figure 5-4: Target 3 Survey Lines

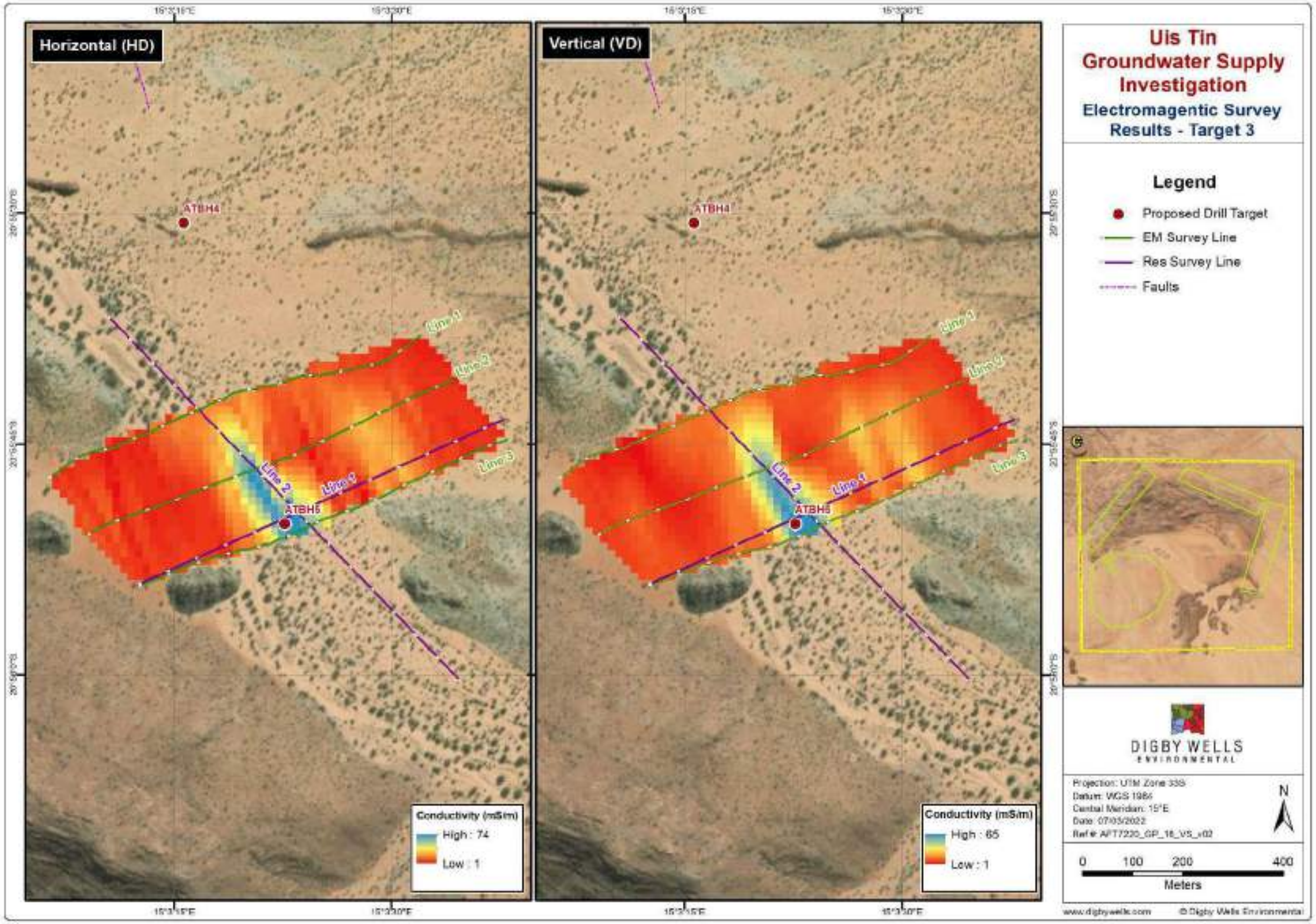

Figure 5-5: Target 3 Contoured EM Results

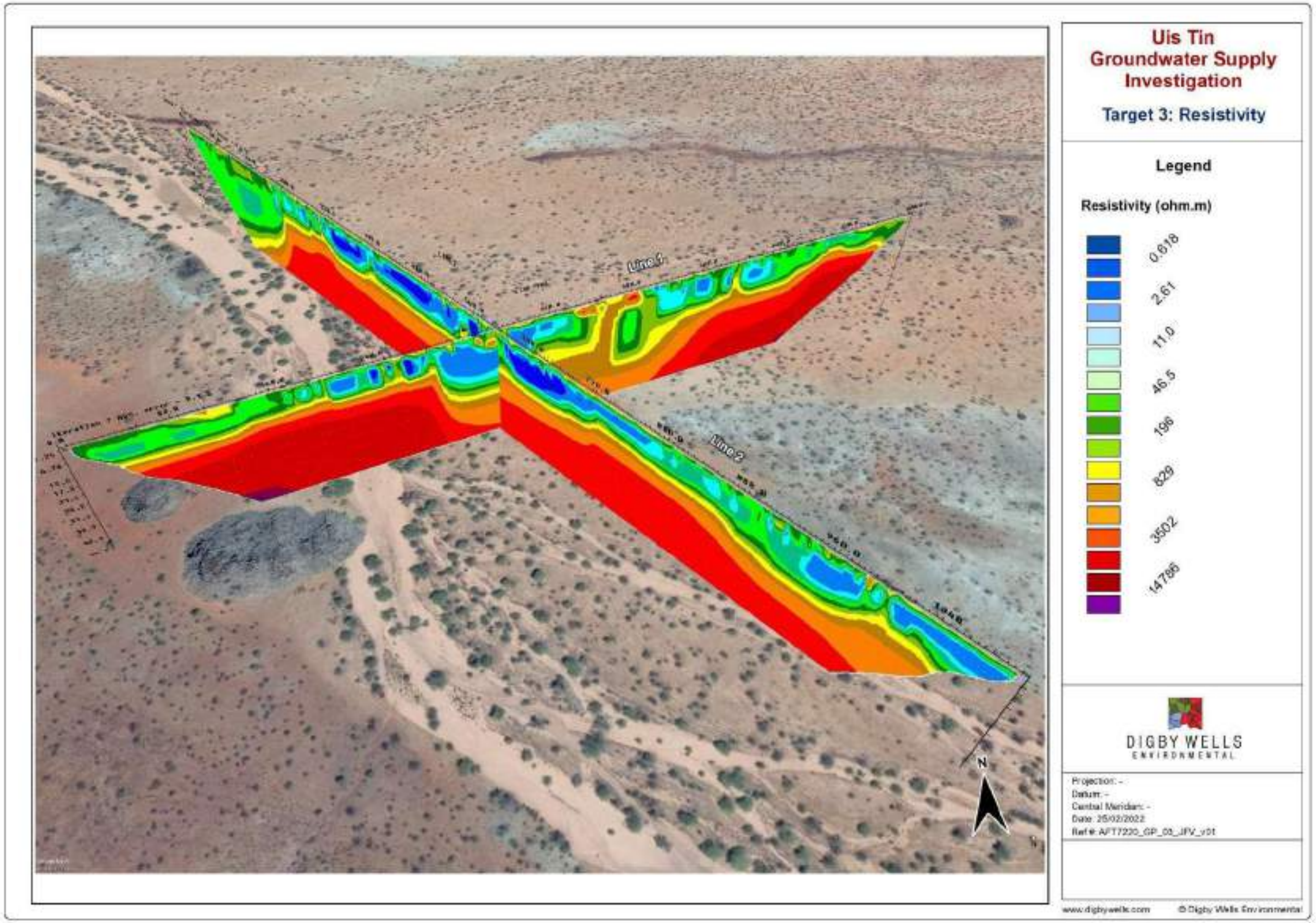

Figure 5-6: Target 3 Resistivity Profiles

5.3. Target 5

Target 5 is located approximately 55 km northwest of the Uis Tin Mine. This target is characterised by a marble unit. The marble unit is crossed by the Ugab River upgradient of the target which could provide a potentially sustainable source of recharge via fractures (if present). An alluvial aquifer is also present in this area which drains the catchment area in a north-westerly direction. The catchment area is large with tributaries starting approximately 33 km southeast of the target area. The tributaries of the alluvial aquifer are located in the low recharge zone however the marble has a potentially higher recharge potential in this area.

Three (3) EM survey lines and two (2) resistivity lines were walked for this target (Table 5-3 and Figure 5-7).

Table 5-3: Target 5 Survey Lines

Method	Label	Start		End		Length (m)	Direction
		Longitude	Latitude	Longitude	Latitude		
EM	Line 1	518249	7698764	517948	7697995	800	NNE-SSW
	Line 2	518150	7698768	517948	7698017	800	NNE-SSW
	Line 3	518072	7698772	517940	7698048	800	NNE-SSW
Res	Line 4	518424	7698975	517909	7698138	1 000	NE-SW
	Line 6	518386	7698801	518094	7698303	600	NE-SW

The contoured EM results indicate a range of conductivities between -10 – 14 mS/m, with the higher values representing rocks which are more conductive. The EM results (Figure 5-8) identified a high conductive feature aligning with the stream channel as well as on the north-eastern area of the contoured results. A kraal fence may have influenced the results on the north-eastern area. The resistivity lines were planned to survey both these features.

The resistivity profiles are shown with the same resistivity range as Target 2 (0.6 – 14 786 ohm.m) (Figure 5-9).

The profiles show that the surface (top) zone is more resistive than the previous targets, with high resistivity clusters near surface of greater than 829 ohm.m. There is however still a weathered zone of approximately 6 - 15 m thick with a range in resistivity of between 47 – 196 ohm.m.

Both profiles show a high resistive feature of approximately 3 502 ohm.m. This feature occurs between stations 440 – 560 in Profile 4 and between stations 290 – 510 in Profile 6 and corresponds to a grey rock exposure in the aerial imagery. Field notes made during the EM survey indicate this rock is fractured granite. The stream from the northeast and the southeast diverts around the southern edge of this rock exposure which competent based on the high resistivity feature. The rocks with a resistivity of between 829 – 3 502 ohm.m in these profiles would correspond to granite and felsic pyroclastic rocks as mapped on the

1:250 000 geological map. The dip direction measurements in the felsic pyroclastic rocks indicates that there is a dip towards the south in the Target 5 area.

There is a low resistivity feature (11 – 196 ohm.m) at the northern contact with the felsic pyroclastic rocks. The feature occurs to a depth of approximately 30 m indicating this may represent a weathered feature or if fractured that the fractures are limited to shallow depths. Another low resistivity feature is present between station 570 – 680 on Profile 4 with a range in resistivity between 196 – 829 ohm.m. This feature may be connected to the deeper low resistive feature on Profile 6 with the same range in resistivity. This feature may be representative of preferential weathering underneath the more competent feature or the presence of marble (if dipping in the same direction as the felsic pyroclastic rocks). Two drill targets (Table 6-1) are proposed to intersect this low resistive feature one on each profile.

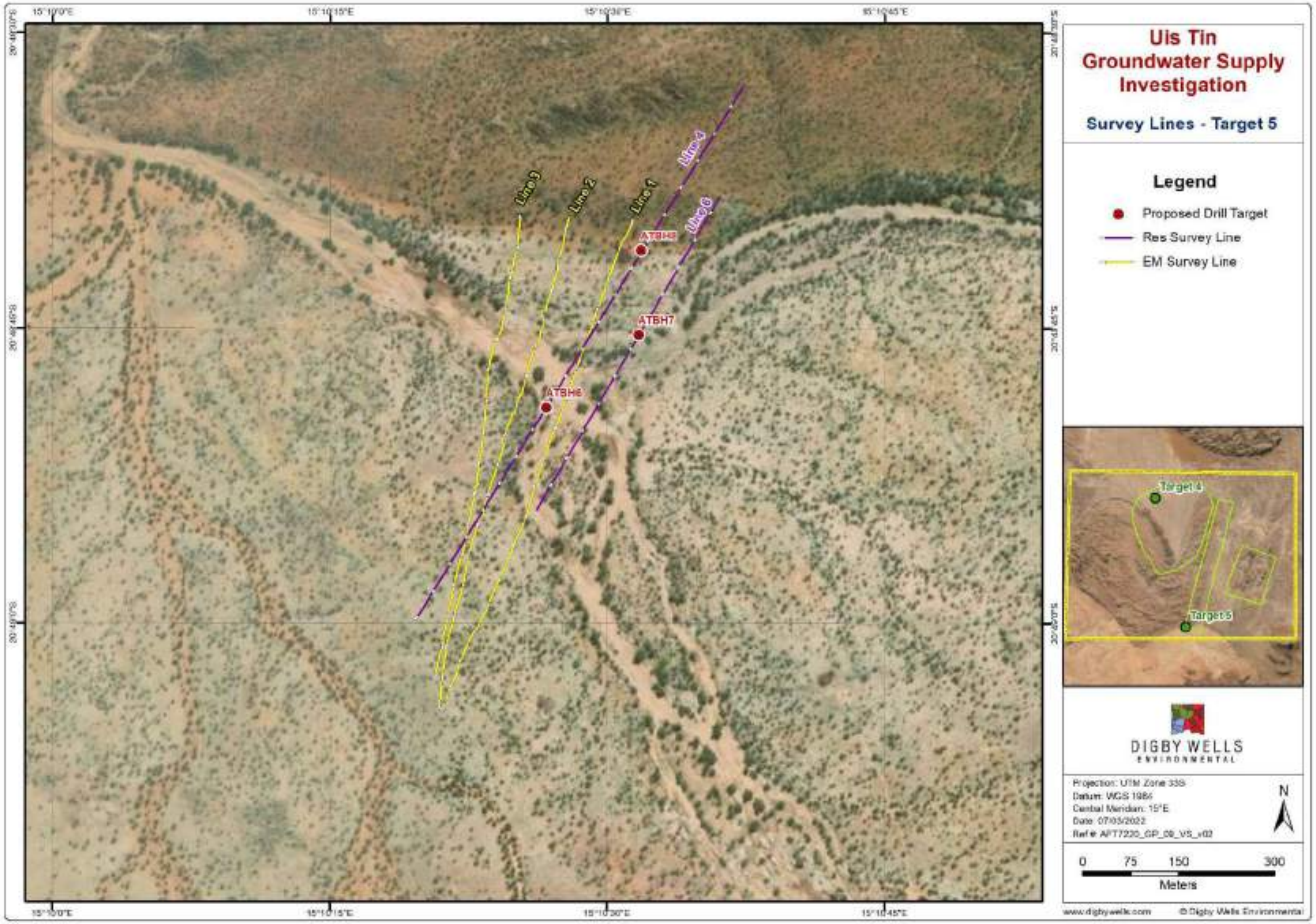

Figure 5-7: Target 5 Survey Lines

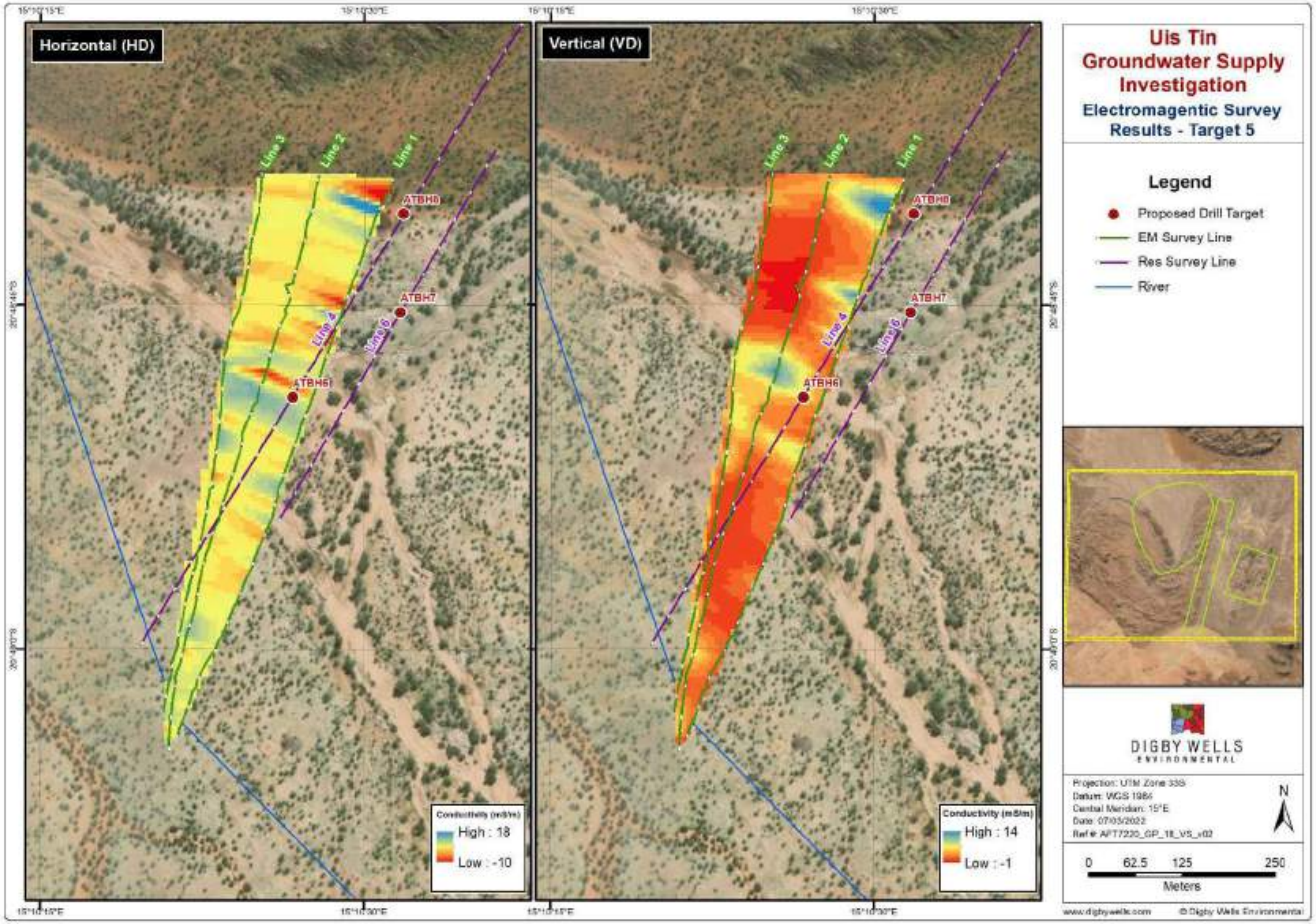

Figure 5-8: Target 5 Contoured EM Results

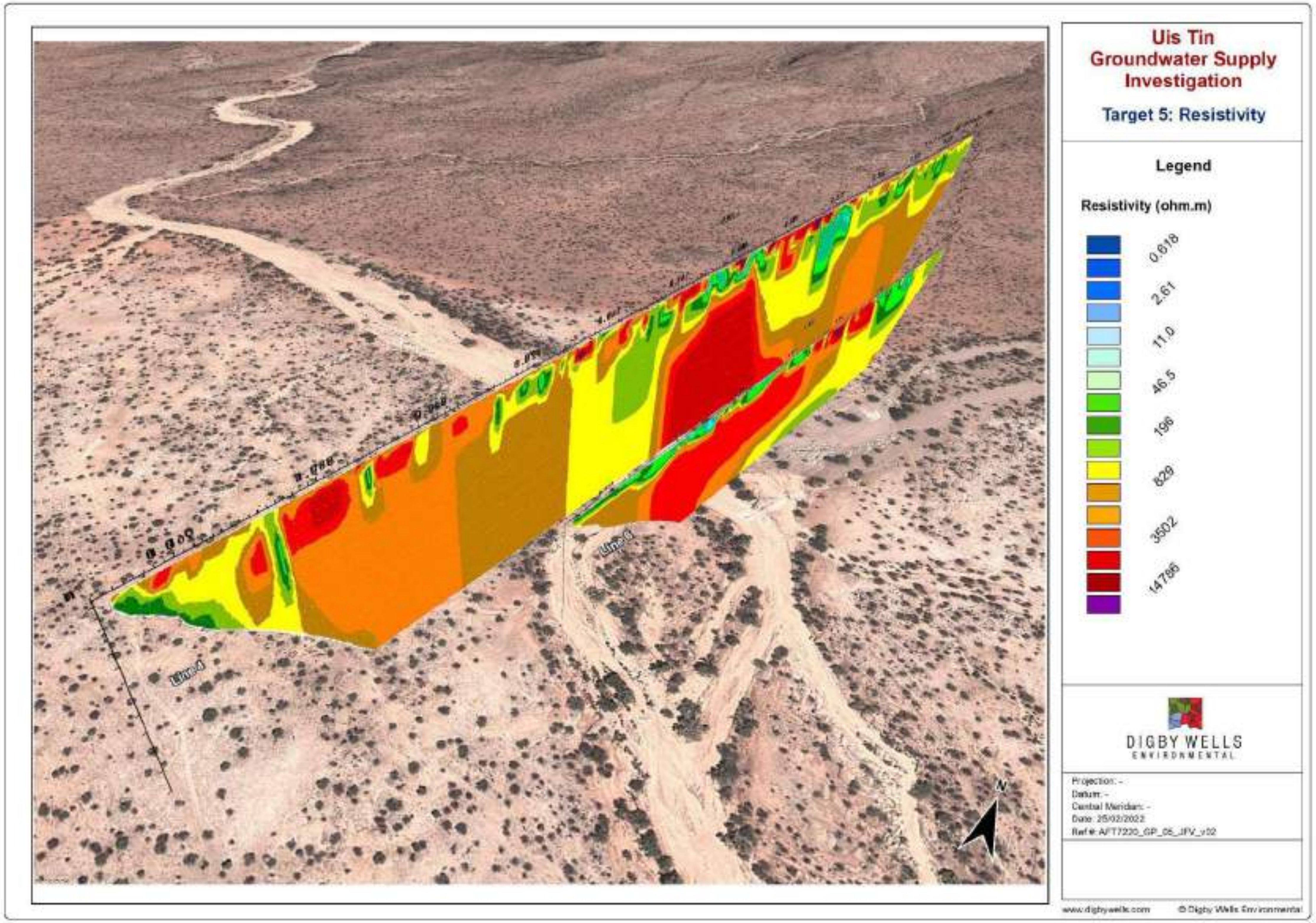

Figure 5-9: Target 5 Resistivity Profiles

6. Conclusion

Six (6) target areas were identified at desktop level with potential marble and/or alluvial aquifer systems. Within these target areas eight locations were identified as potential geophysical survey areas. These eight locations were prioritised to the three locations which could be surveyed with EM and resistivity geophysical survey methods.

Target 2 surveyed an alluvial aquifer with the potential to have high yielding boreholes (an existing borehole with an estimate yield of 27 m^3/hr is potentially located near to this target area). Two drilling targets were identified from the geophysical survey data for this target.

Target 3 surveyed a potential regional fault which intersects marble unit. There is an alluvial aquifer flowing across this location as well which could assist with recharging the fault and/or marble aquifer. One drill target was identified from the geophysical data for this target.

Target 5 surveyed a potential marble unit with an alluvial aquifer (with a large catchment area) potentially supplying a source of recharge to the marble aquifer. Two drilling targets were identified from the geophysical survey data for this target.

A total of eight (8) drilling targets have been proposed which are summarised in Table 6-1.

The boreholes should be drilled using air-percussion drilling methods. Boreholes should be drilled to a final end-of-hole diameter of 8 inches. Should a borehole intersect yields of greater than 20 m^3/hr, the borehole will need to be reamed to a larger diameter. Screened PVC casing should be installed in all boreholes which intersect a water strike to prevent collapse of the borehole. The annulus of the borehole must be filled with 3 – 5 mm silica sand/gravel until approximately 1 m below surface. A 1 m bentonite seal should be installed at surface to prevent surface contamination from entering the borehole.

After the boreholes have been drilled and constructed, they will need to be aquifer tested to verify the sustainable yield of the borehole. A four (4) hour step test followed by a forty-eight (48) constant discharge test should be performed on all successful boreholes. During the aquifer test, samples should be collected for analysis to determine the groundwater quality.

Table 6-1: Proposed Drill Targets

Geophysical Target	Drill Target	Longitude	Latitude	Proposed Depth (m)	Priority	Resistivity Station	Comment
Target 2	ATBH1	498914	7678037	80	High	Line 5 - 70	
Target 2	ATBH2	498616	7677743	80	Low	Line 3 - 570	
Target 2	ATBH3	498907	7677846	80	High	Line 3 - 270	
Target 3	ATBH4	505650	7686133	100	High	-	This target is projected off the original survey profiles and may need to be resurveyed to confirm the fault location
Target 3	ATBH5	505852	7685532	80	High	Line 1 - 310	
Target 5	ATBH6	518114	7698470	100	High	Line 4 - 600	There were community issues when surveying Target 5. Water supply may be requested if boreholes are drilled here.
Target 5	ATBH7	518258	7698584	100	High	Line 6 - 250	
Target 5	ATBH8	518262	7698716	80	Low	Line 4 - 320	

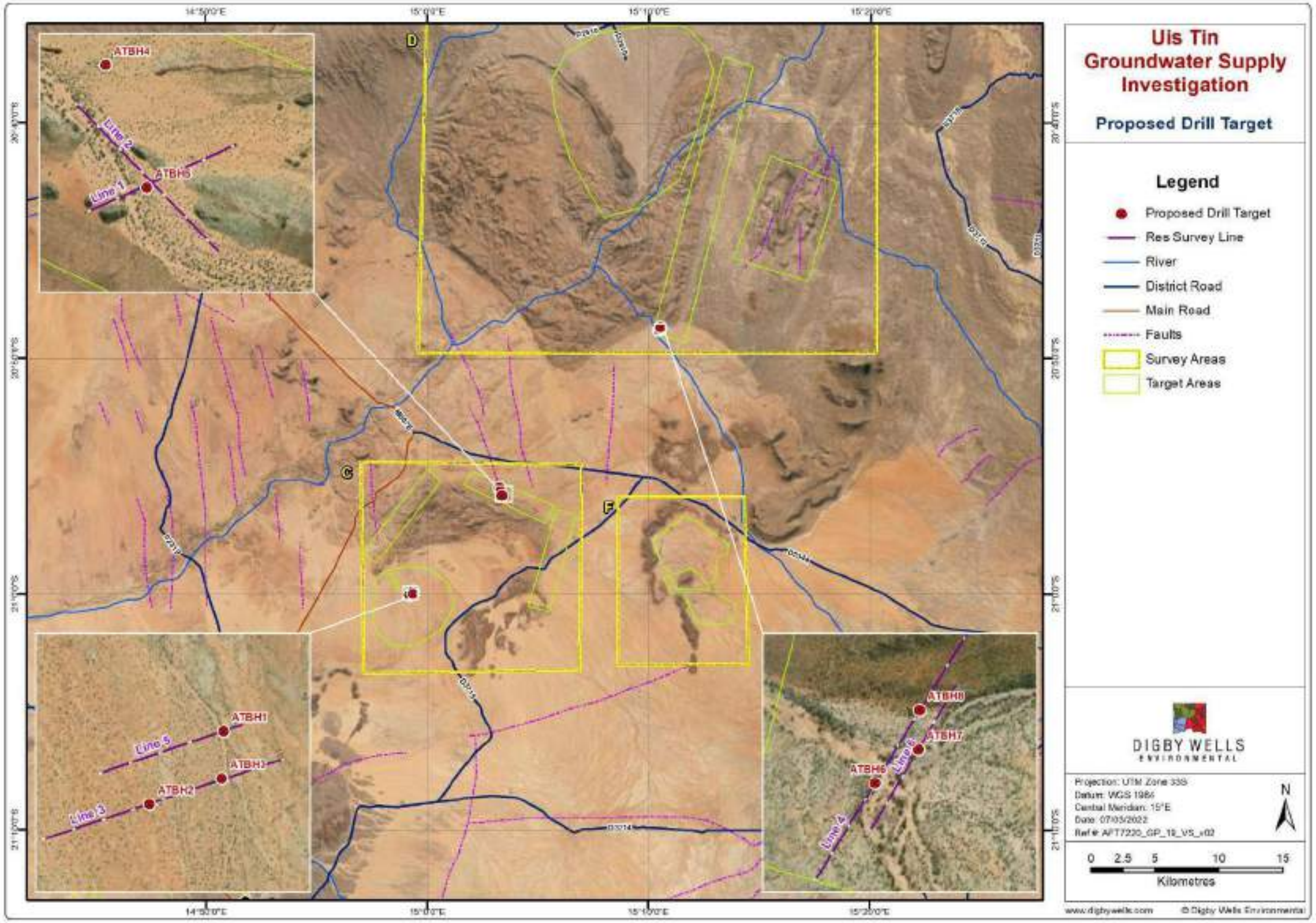

Figure 6-1: Proposed Drill Targets

7. Recommendations

The following additional recommendations are proposed:

- It is recommended to locate the existing boreholes within the six (6) target areas and if located determine if they can be used by the mine. The boreholes which can be used will need to be aquifer tested to confirm their sustainable yields. Should the existing boreholes all be located, and the estimate yield confirmed the existing boreholes could potentially provide 279 m^3/hr.

8. References

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Appendix A: Methodology

Electromagnetic Method

Nine (9) survey lines were investigated using the electromagnetic geophysical survey method using an a two-man portable EM 34 instrument with 20 m coil separation. Both the horizontal (HD) and vertical (VD) dipole modes where applied. These modes measure the out-of-phase component of the induced electromagnetic field, which gives an indication of the subsurface conductivity.

Electrical Resistivity Tomography Method

Six (6) survey lines were investigated using the electrical resistivity tomography geophysical survey method using the ABEM Terrameter LS 2. Electrical Resistivity Tomography (ERT / Resistivity / Res) is a geophysical survey method measuring resistivity, which is a physical property of materials that describes how difficult it is for an electrical current to pass through the material.

The LS2 instrument was setup using four (4) 100 m cables with 5 m electrode spacing. The 5 m electrode spacing allows for a mean survey depth of approximately 60 m. The resistivity survey was conducted using the wenner-α array, which is a four (4) electrode setup that is less sensitive to noise and has a high signal to noise ratio reducing the potential for errors.

Data Processing

The 2D resistivity data was processed using a de-spiking and predictive error analysis method to remove readings which are known to be incorrect. The data was corrected for the following issues:

- Noisy data (e.g., negative values or large single data point anomalies) was removed;
- Linear interpolation was undertaken to removed singular noisy data points;
- A preliminary inversion was run using RES2DINV software. Data points with large RMS errors were excluded using the RMS error statistics bar chart algorithm available within the RES2DINV software;
- The final inversion is presented in this report as 2D tomographs (or profiles) and as a google earth .kml file to assist with spatially viewing the profiles; and
- The resistivity profiles were georeferenced to the survey line locations (Figure 2 and Figure 3) to spatially view the profile results.

Interpretation

The following factors influence the interpretation of the resistivity and IP survey results:

- Porosity, pore saturation and pore fluid can affect the resistivity of rocks. Pore spaces can be filled with air (unsaturated pores) and/or fluids (saturated pores). The properties of air make it very resistive to transmitting a current, thereby forcing the current to flow through the minerals comprising the rock resulting in high resistivity responses. Pore-fluids (which comprise of fresh, brackish, or saline water) however have a higher conductivity compared with most rock forming minerals and as a result a current is more likely to flow through saturated pore spaces (discussed further under tortuosity);

- The complexity and connectivity (tortuosity) of pore spaces can affect the resistivity characteristics of rocks. Tortuosity determines how effectively a current is transmitted through the rock. Rocks with low tortuosity have simple flow paths resulting in more conductive (less resistive) characteristics. As the tortuosity increases so does the resistivity of the rock; and
- Presence of mineralisation within the rocks can affect the resistivity of rocks. Electrical currents preferentially flow through minerals which are more conductive than the pore fluids. Native metals, metal-oxides and metal-sulphides frequently present in ore-bearing rocks as well as graphite have properties which make them more conductive than pore fluids, which lower the resistive properties of the rocks.

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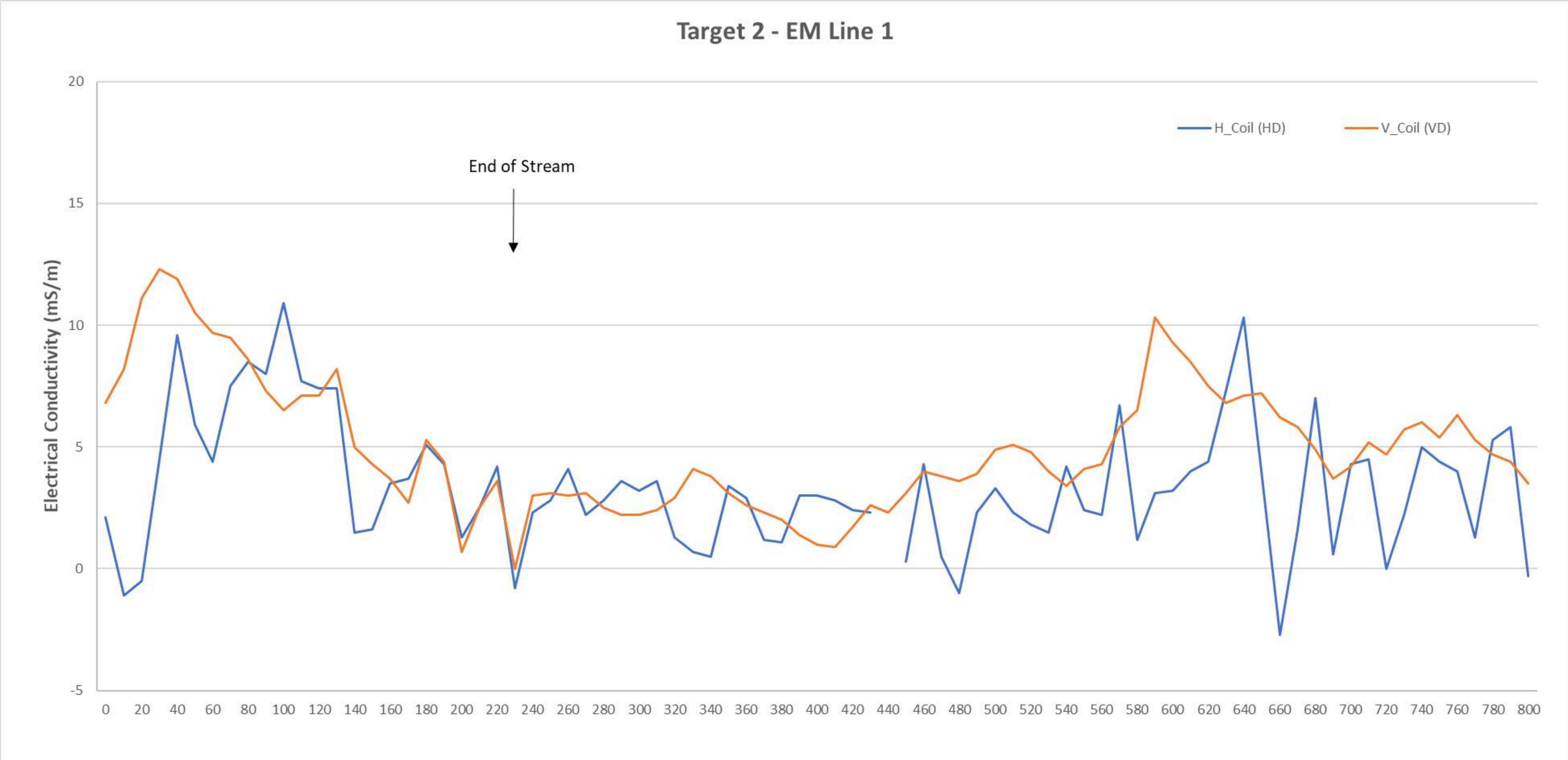
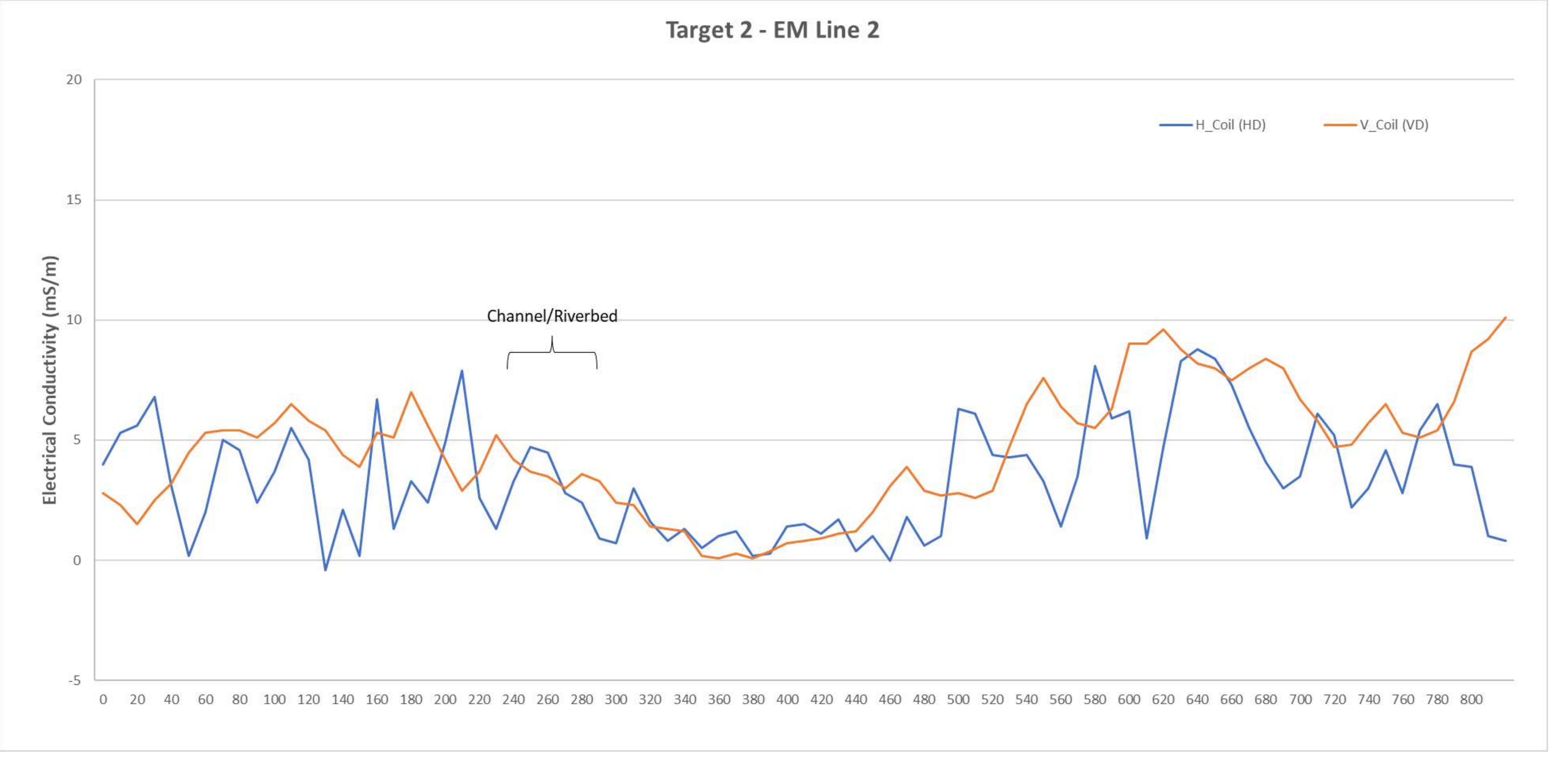
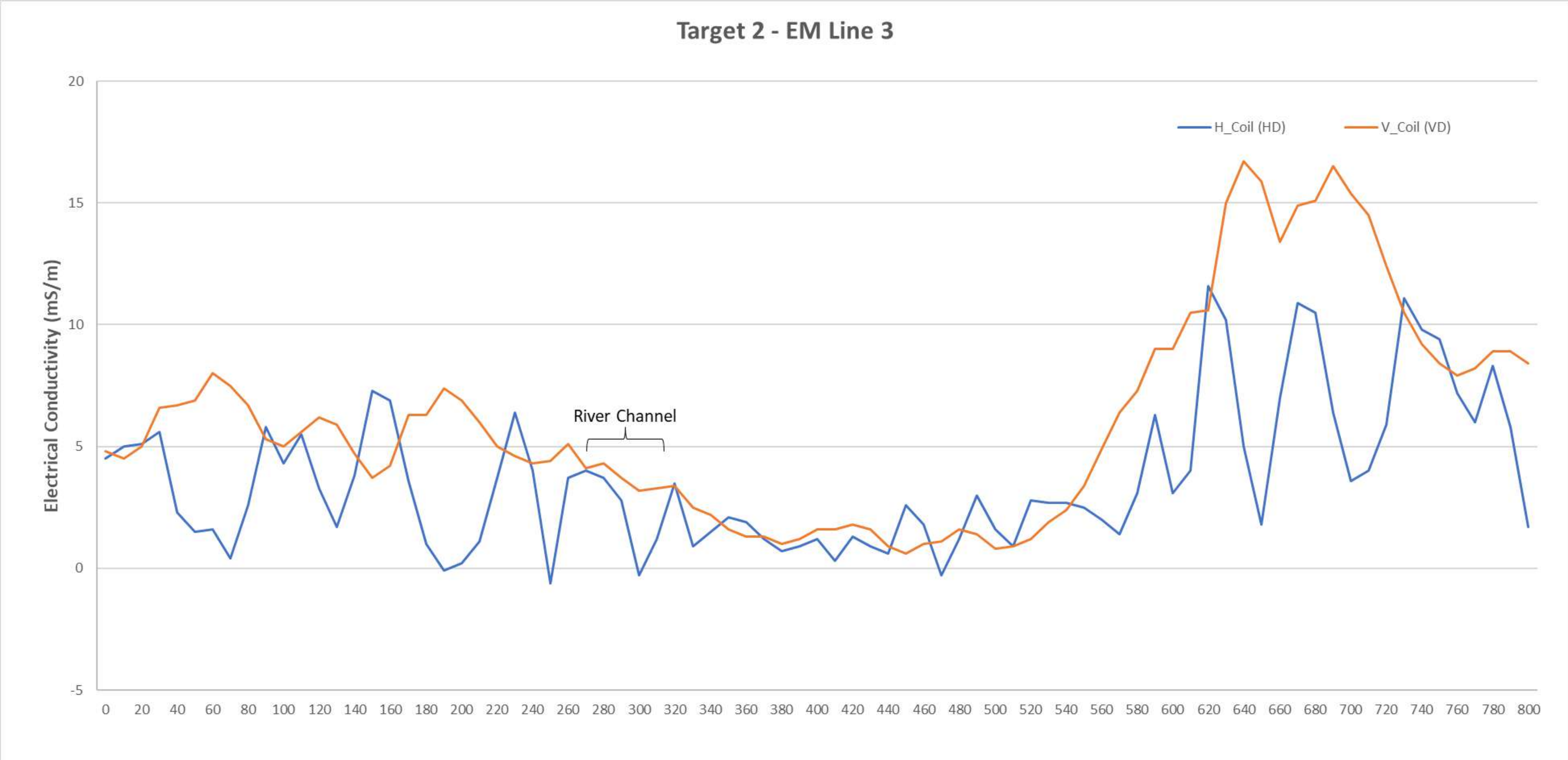
Appendix B: Electromagnetic and Resistivity Profiles



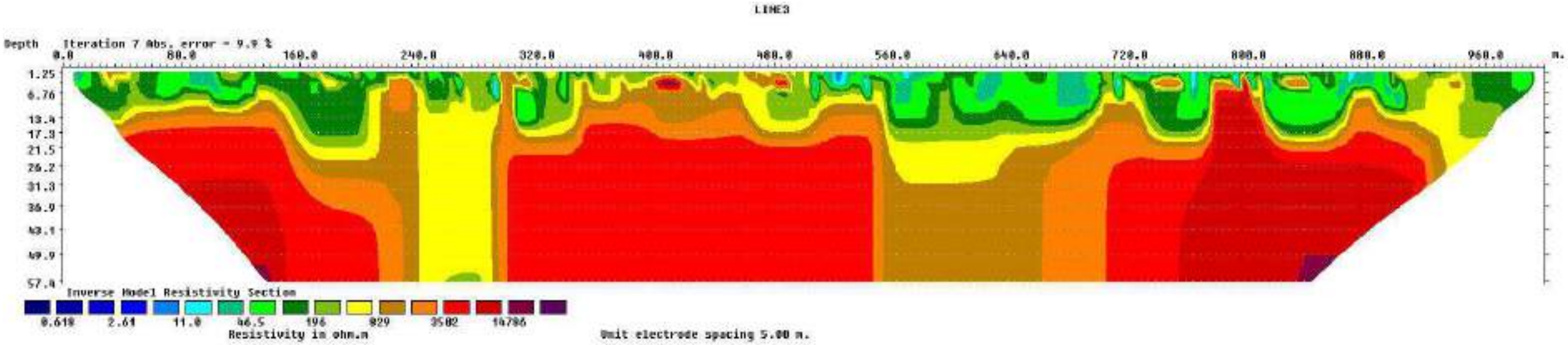
Target 2 EM Profile 1



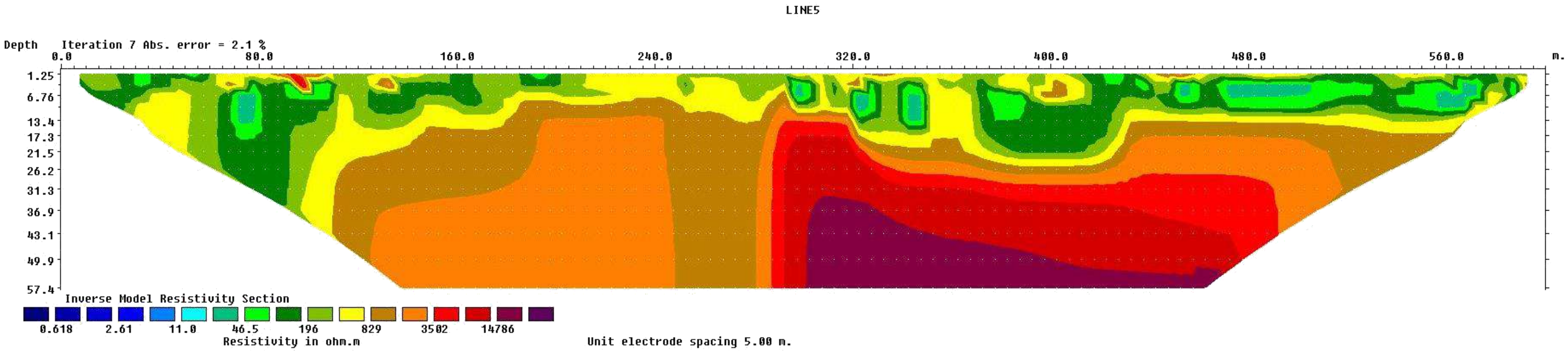
Target 2 EM Profile 2



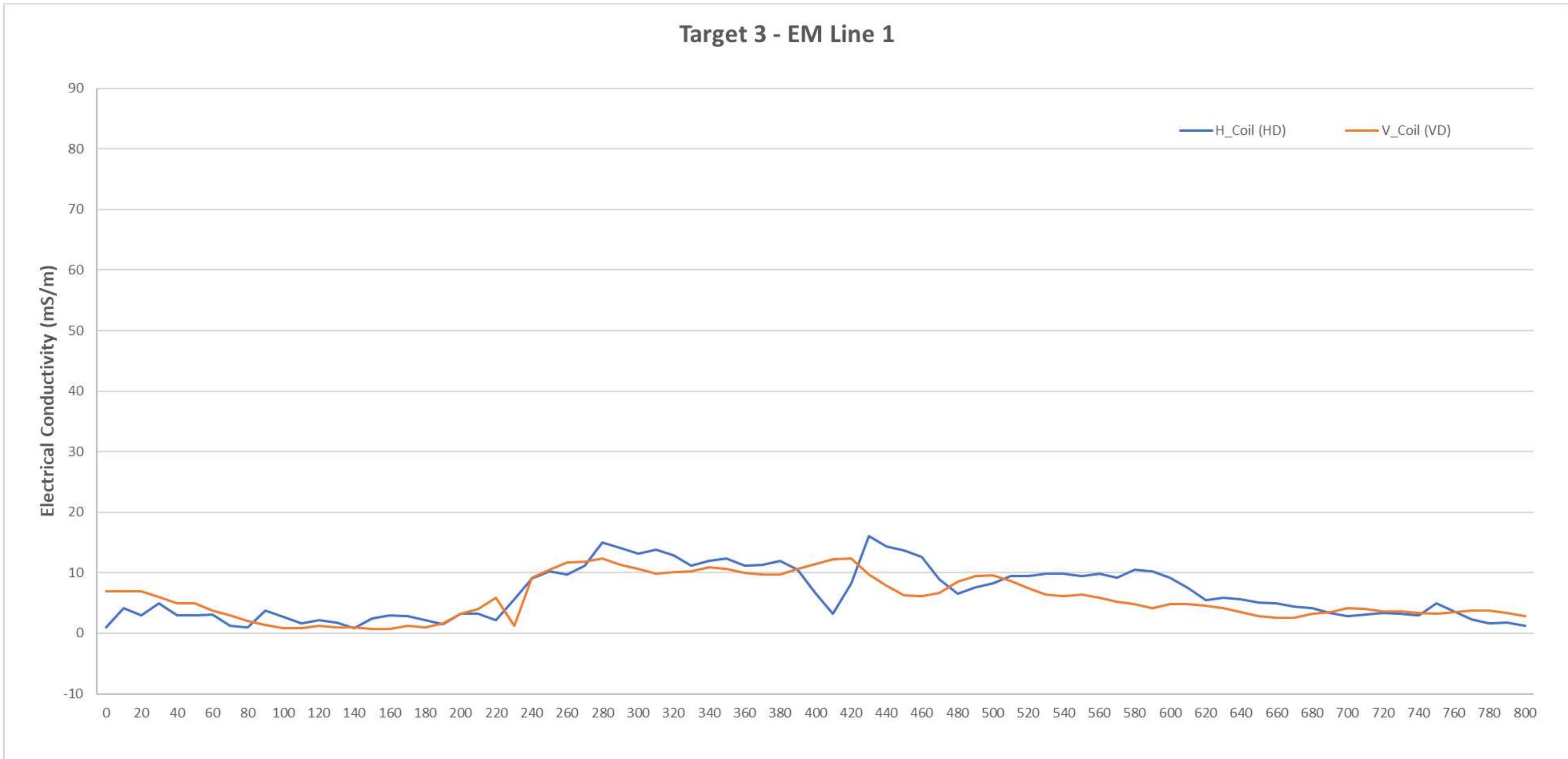
Target 2 EM Profile 3



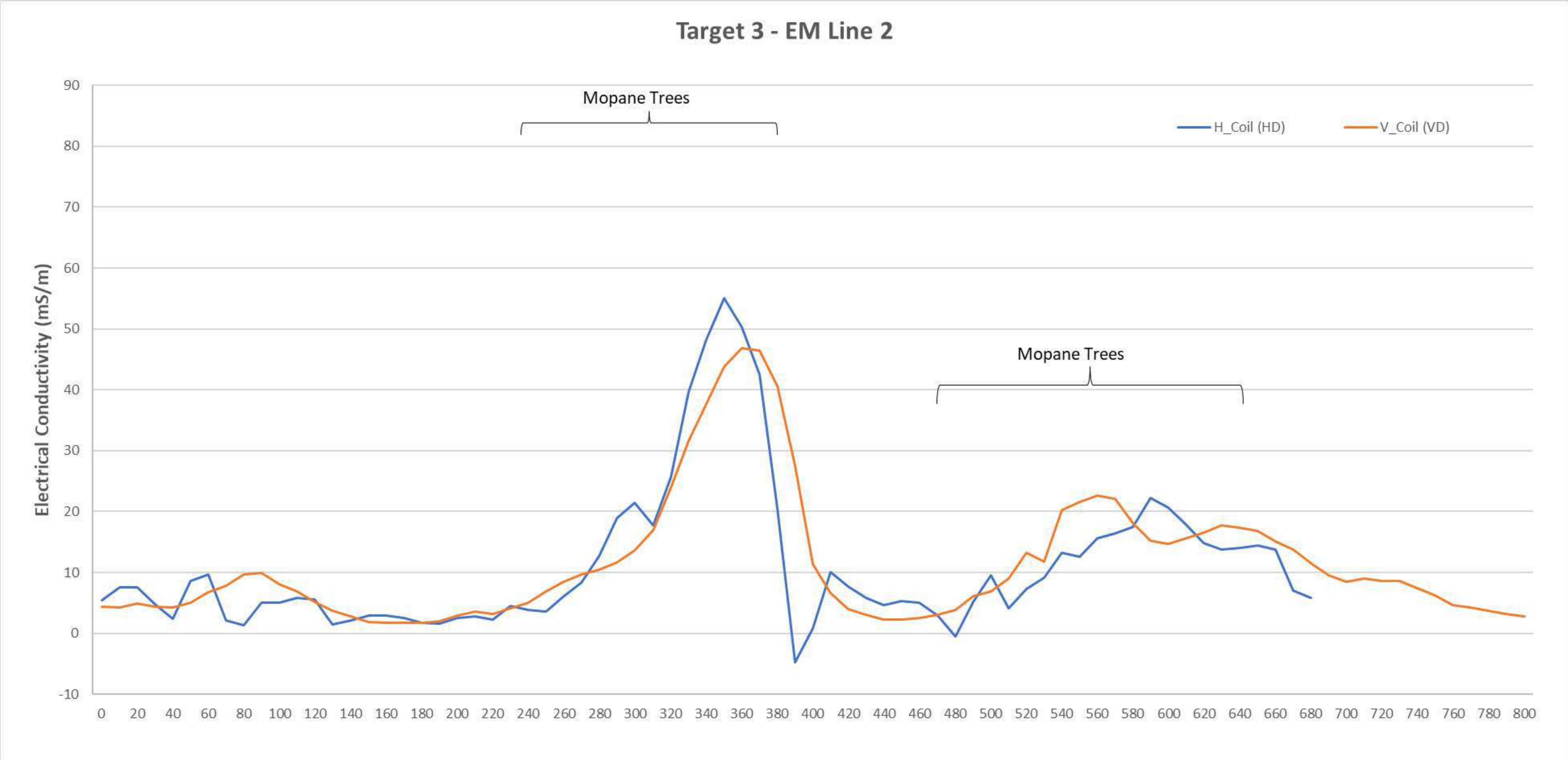
Target 2 Resistivity Profile 3



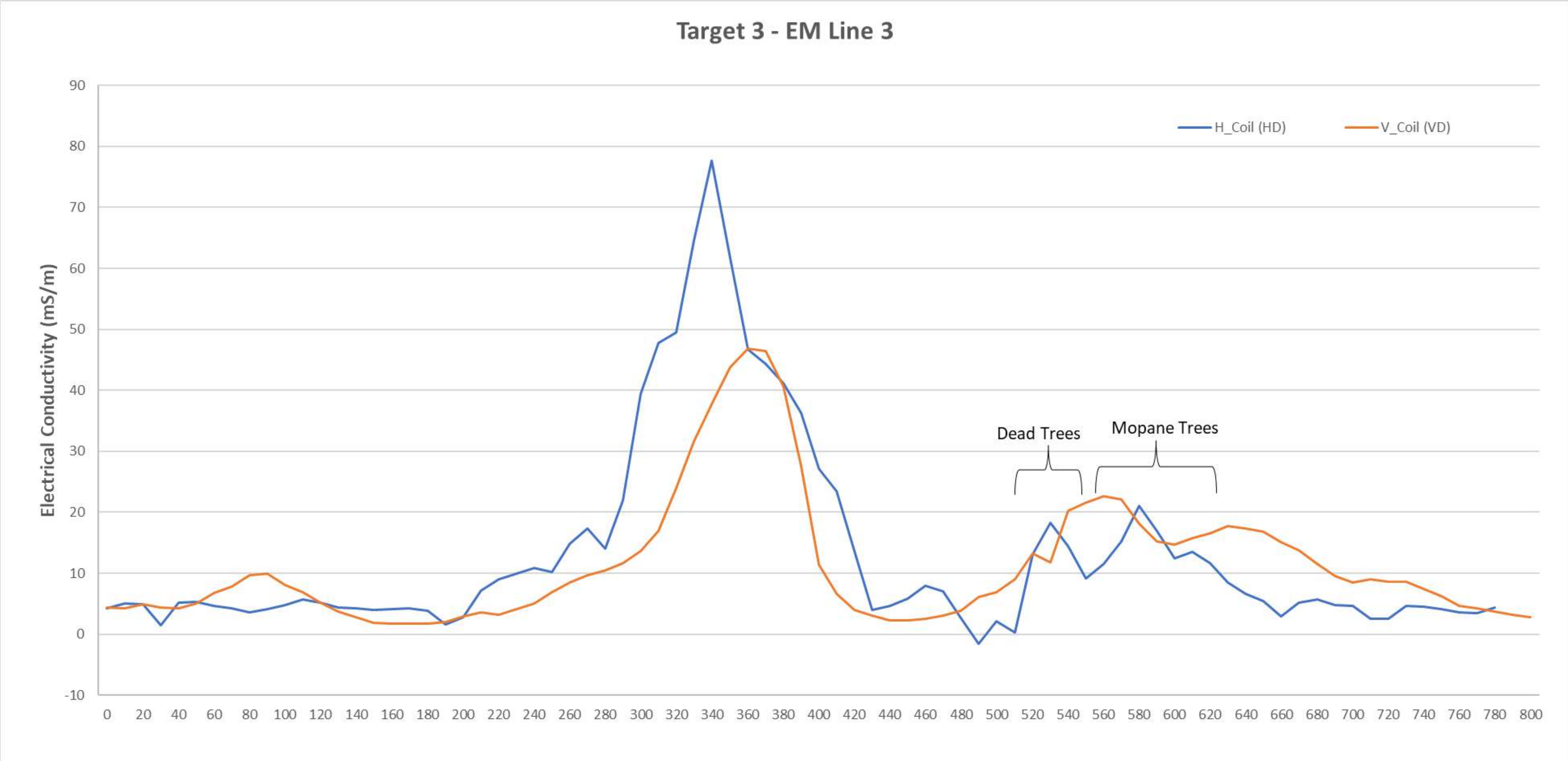
Target 2 Resistivity Profile 5



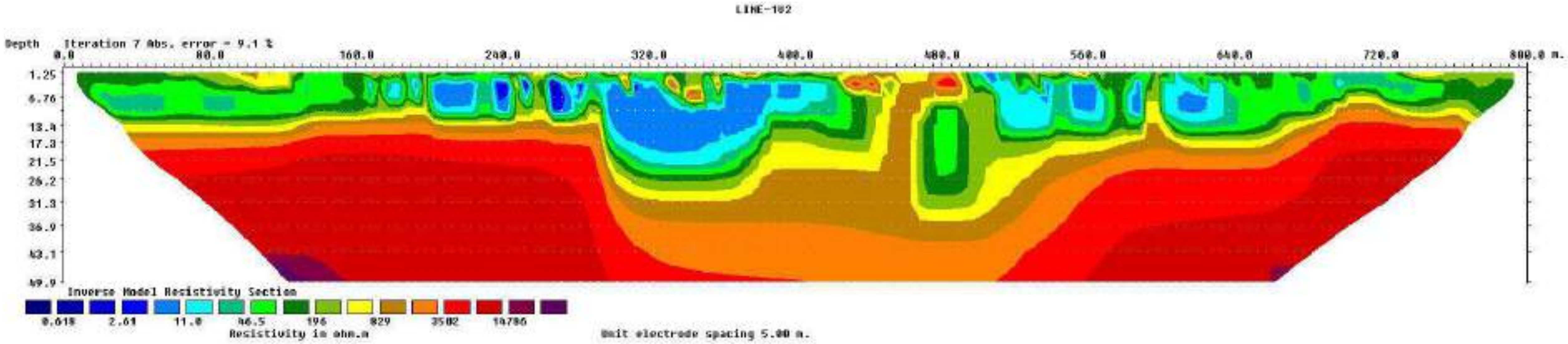
Target 3 EM Profile 1



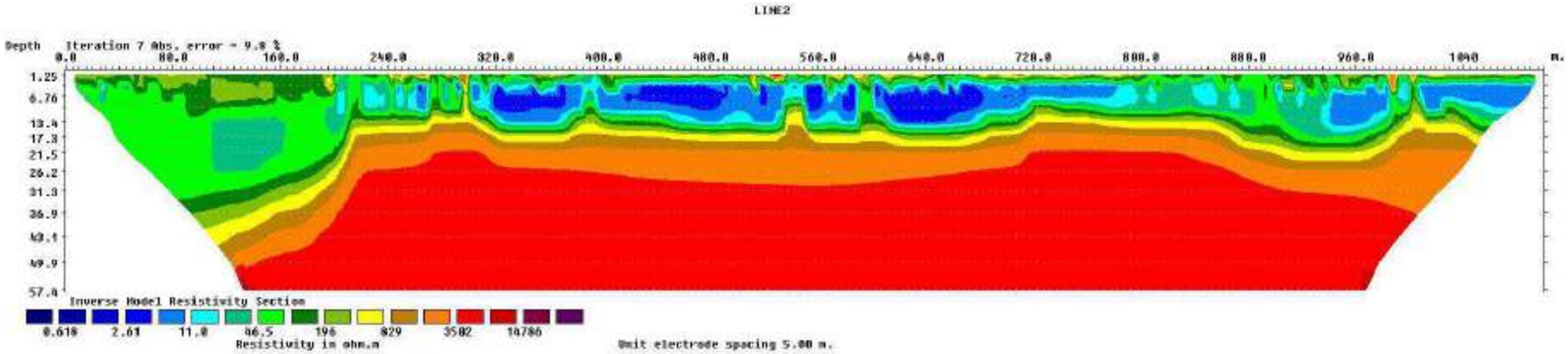
Target 3 EM Profile 2



Target 3 EM Profile 3



Target 3 Resistivity Profile 1



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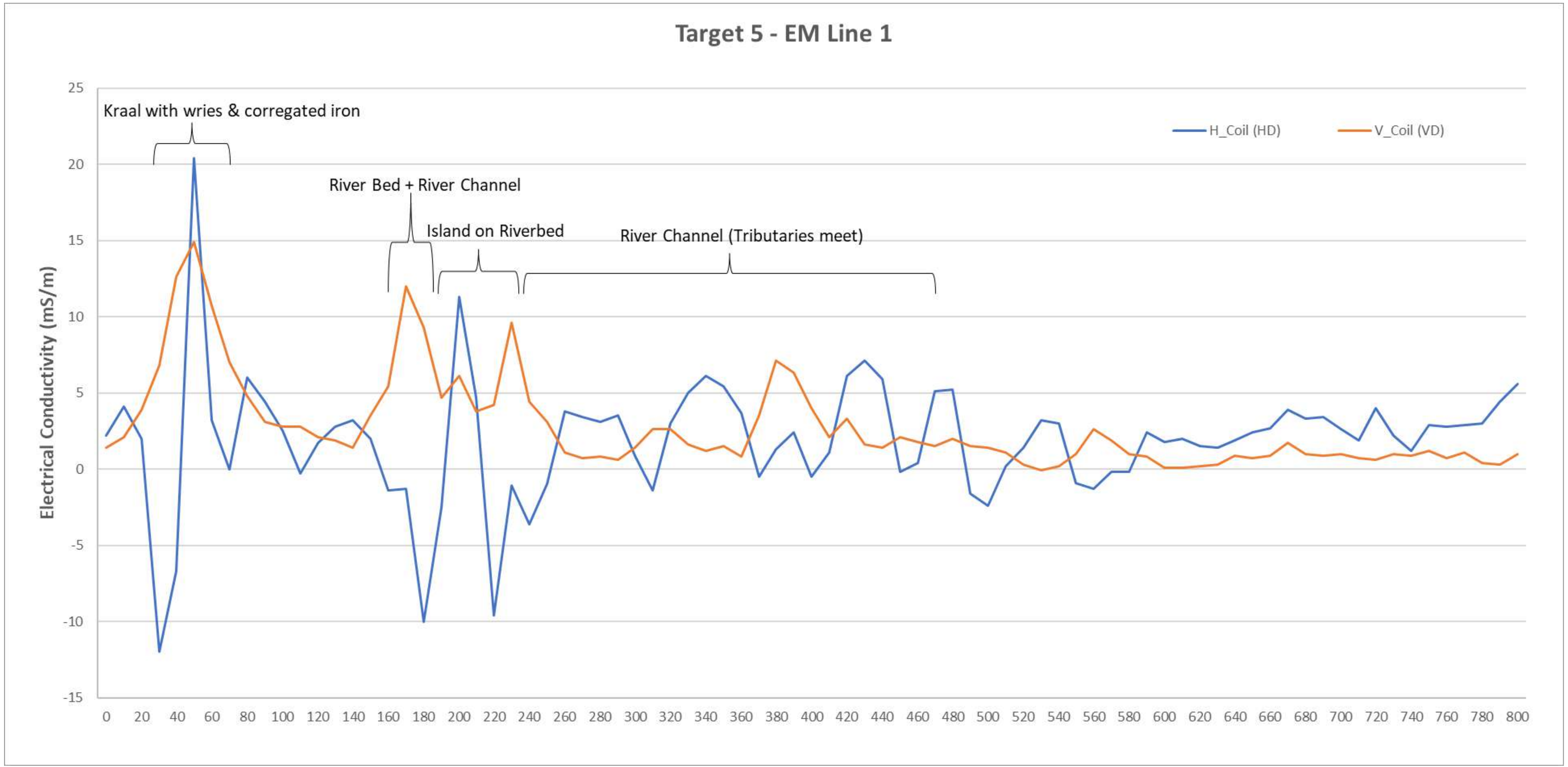
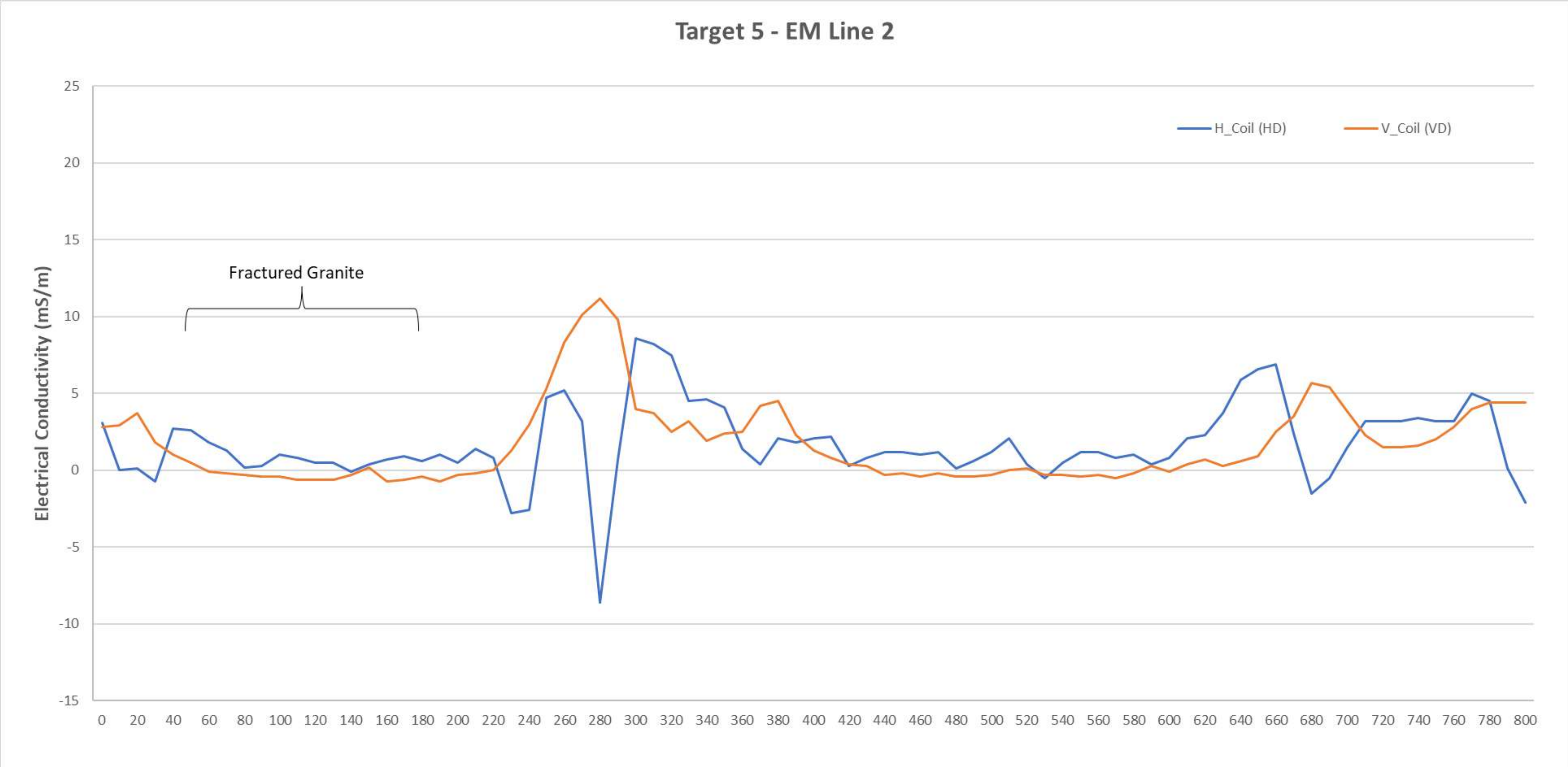
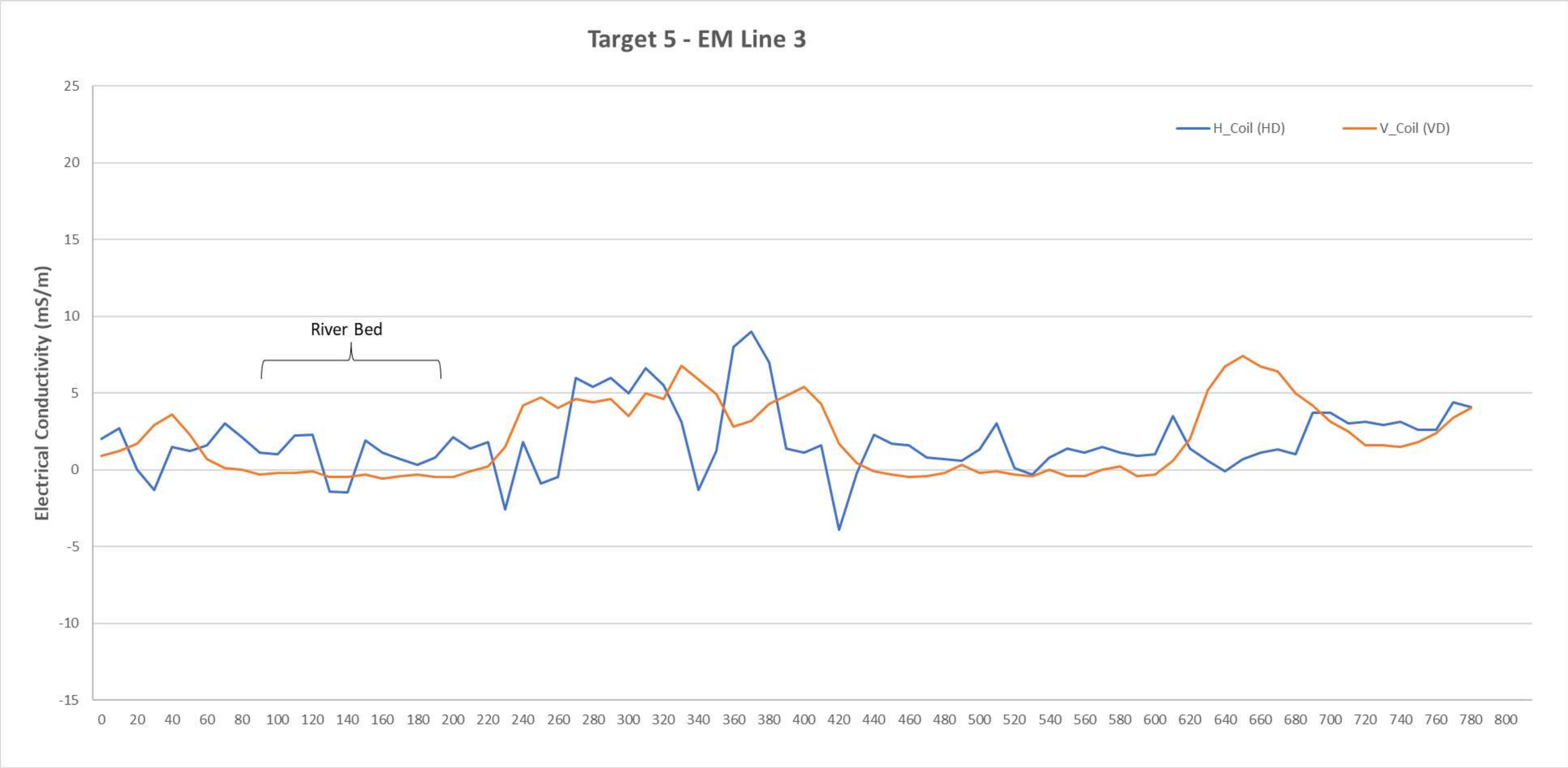


Target 5 EM Profile 1



Target 5 EM Profile 2



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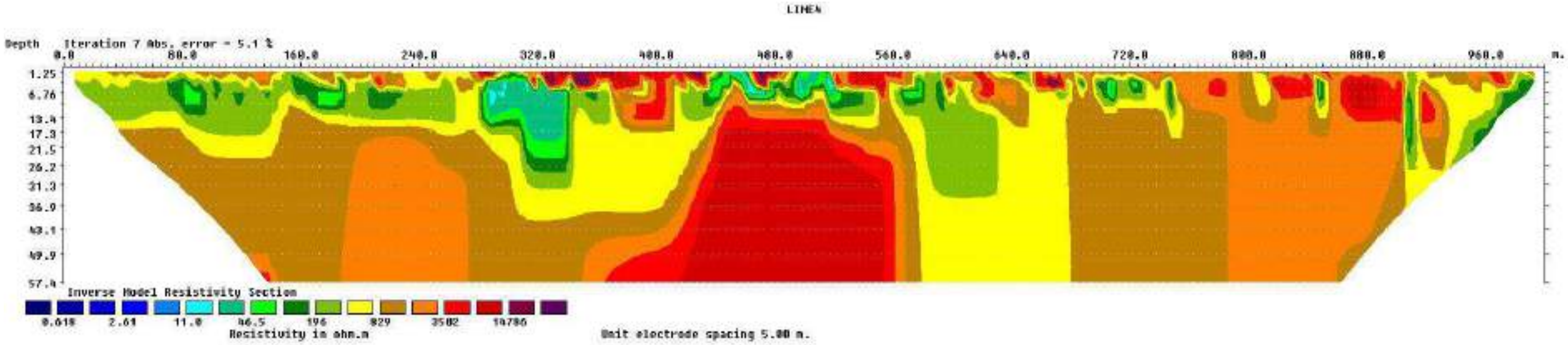
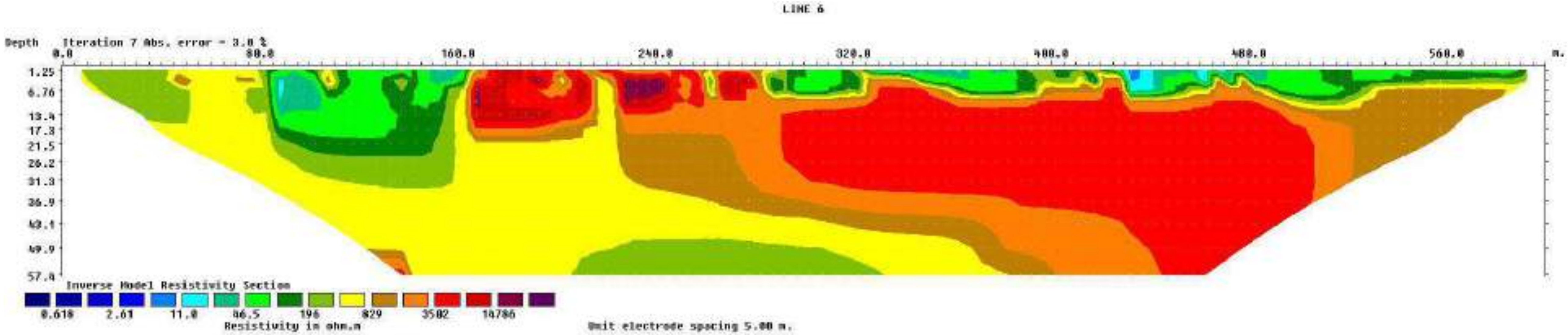


Target 5 Resistivity Profile 4



Target 5 Resistivity Profile 6

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Groundwater Supply Investigation for the Uis Tin Project, Namibia

Hydrogeological Assessment

Prepared for:

AfriTin Mining (Namibia) (Pty) Ltd

Project Number:

AFT7220

June 2022

Digby Wells and Associates (Pty) Ltd
Company Registration: 1999/005985/07

Turnberry Office Park,
Digby Wells House.
48 Grosvenor Road,
Bryanston,2191

Phone: +27 (0) 11 789 9495
Fax: +27 (0) 11 789 9498
E-mail: info@digbywells.com
Website: www.digbywells.com

Directors: J Leaver (Chairman)*,
NA Mehlomakulu*, DJ Otto, LF Stevens,
GE Trusler, RA Williams*
*Non-Executive

This document has been prepared by Digby Wells Environmental.

Report Type:	Hydrogeological Assessment
Project Name:	Groundwater Supply Investigation for the Uis Tin Project, Namibia
Project Code:	AFT7220

Name	**Responsibility**	**Signature**	**Date**
Megan Edwards	Report Writer		30 June 2022
Arjan van ‘t Zelfde	Numerical Modeller and Report Review		30 June 2022
Andre van Coller	Report Review		30 June 2022

EXECUTIVE SUMMARY

Digby Wells Environmental (hereinafter Digby Wells) was appointed by AfriTin Mining (Namibia) (Pty) Ltd (hereinafter AfriTin) to undertake a water supply assessment for their planned expansion of production at the Uis Tin Mine, in Namibia.

The pilot plant is currently producing ~65 tonnes of tin concentrate per month for Phase 1 Stage I, with a water demand of ~0.288 Ml/day (12 m^3/hr). The expansion of the pilot processing plant to Phase 1 Stage II will increase production at the mine to ~100 tonnes of tin concentrate per month, which will increase the water demand of the plant to ~0.432 Ml/day (18 m^3/hr). Water is currently sourced from water supply boreholes in the Uis River channel as well as contributions from water stored within the K5 pit and this investigation assesses whether the water supply boreholes can meet the increased demand for the planned 18-year Life of Mine of the Phase 1 Stage II expansion.

A later Phase 2 expansion plans to increase production to ~1 250 tonnes of tin concentrate per month.

Baseline

The project area is characterised by fractured igneous and metamorphic rock aquifers which are overlain by shallow alluvial aquifers in river channels and as surface cover in some areas. The aquifers receive low recharge, with ~0.7% of rainfall (average of 88 mm/a) reaching the aquifer. Stormwater runoff flows via the Uis River tributary towards the Ugab River located to the north of the project area. The mine is located on the Uis River near the water divide between the Ugab and Omaruru River Catchments.

Water supply boreholes for the mine have been drilled in the Uis River and an unnamed river tributary to the south of the mine, which comprise the Uis and Southern wellfields. The alluvial aquifer in these channel has an average thickness of 5.5 m and are important for recharging the underlying fractured aquifers. The fractured aquifer is weathered to an average depth of 25 m and has a higher fracture frequency to depths of 50 m. Although the fracture frequency decreases below 50 m, high yielding fractures can still be intersected in this low fractured aquifer. The groundwater levels (pre-abstraction) range between 15 – 37 mbgl indicating the water table is in the weathered fractured aquifer.

The quality of the groundwater indicates the groundwater has a long residence time in the aquifer, allowing rock-water interaction processes to occur. These processes result in elevated concentrations of chloride, sulphate, sodium, calcium, magnesium and nitrate which elevate the electrical conductivity levels in the groundwater. The groundwater quality is classified as Group D for all water supply boreholes in the Uis and Southern wellfields, which is the highest health risk category and is not suitable for human consumption based on the drinking water guideline limits for Namibia.

Field Assessments

Ten (10) water supply boreholes were aquifer tested by Hammerstein Mining and Drilling between December 2021 and January 2022. The results indicate that the hydraulic conductivities range between 0.1 – 3.5 m/d, with an average of 0.8 m/d and the transmissivities range between 0.6 – 586 m^2/d, with an average of 51 m^2/d. These ranges are comparable to the previous 2018 aquifer test results for the water supply boreholes as well as aquifer parameters available in literature sources.

The aquifer test results were used to determine the sustainable yield for the water supply boreholes. The sustainable yield ranges between 0.2 – 8.5 m^3/hr with a cumulative 18.7 m^3/hr for the 10 water supply boreholes. This yield just meets the demand for the Phase 1 Stage II expansion and therefore it is recommended to locate (potentially three boreholes) or drill additional boreholes to supplement water supply during borehole maintain periods or replace boreholes if scaling or fouling reduces the capacity of existing boreholes.

Numerical Model Findings

The numerical model was used to simulate the sustainable yield (18.7 m^3/hr) abstractions from the water supply boreholes for the planned 18-year Life of Mine and assess the impact of cumulative abstraction from known third-party boreholes.

The simulation indicates that the abstraction of water supply for the mine of 18 m^3/hr is deemed to be sustainable for the planned Life of Mine. However, the aquifer will be stressed due to the low recharge potential in the region. The cone of drawdown will extend over time reaching a maximum of ~6.5 km from the mine with a regional drawdown of ~4.5 m in 2040 (when compared against the current situation) because of the abstractions.

Should there be any significant increases in the demand from the aquifer (by the mine or third-party groundwater users) or as a result of draughts or climate change there may be an impact to the long-term sustainable yield of the wellfields.

Water Management Plan

The Phase 1 Stage II expansion will require 127 440 m^3 per year (at 18 m^3/hr) for the planned 18 years. The water stored within the K5 pit can provide 190 634 m^3 which would supply the plant for ~1.5 years. This can be used to supplement the supply from the water supply boreholes during maintenance periods until the K5 Pit will need to be dewatered for mining to continue.

The sustainable yield from the current water supply boreholes will just meet the demand for the Phase 1 Stage II expansion (at 18.7 m^3/hr) and therefore it is recommended to locate or drill additional boreholes which can be used to supplement water supply during borehole maintenance periods or replace boreholes if scaling or fouling reduces the capacity of existing boreholes.

It is recommended that the water supply boreholes be cleaned every 2-years to remove sediment, debris, roots and deposits of iron, calcium and magnesium from the borehole and/or pumps to maintain the capacity of the boreholes. However, cleaning may be required on a more frequent basis. Frequently monitoring the borehole yields and drawdowns will provide an indication on when boreholes will need to be cleaned.

Current aquifer testing observations indicates that BH2 has a reduced yield compared to what was originally achieved and BH9 has issues with roots and oxide deposits. Cleaning the boreholes may improve the current sustainable yield results which would allow the water supply boreholes to be used in a more flexible schedule rather than all boreholes operating for ~20 hours per day every day.

The groundwater monitoring programme must include daily rainfall measurements, weekly groundwater level measurements (in actively used water supply boreholes), quarterly groundwater level measurements (in unused water supply boreholes) and water quality sampling which will allow the mine to timeously detect any changes in the aquifers which may affect the water supply potential so alternative water sources can be investigated and implemented.

Conclusions

- The yield demand for the Phase 1 Stage II expansion of 18 m^3/hr can be provided by the existing water supply boreholes which have a combined sustainable yield of 18.7 m^3/hr based on the interpreted aquifer test results;
- The groundwater quality is not suitable for human consumption, however it can be used as raw water supply in the plant;
- Based on the numerical model simulations the water supply abstractions is deemed to be sustainable, however the water supply abstractions will stress the aquifer due to the low recharge potential of the region. The cumulative abstractions for the proposed 18-year Life of Mine will create a drawdown cone with a maximum extent of ~6.5 km and a drawdown of ~4.5 m;
- Should there be any significant increases in demand from the aquifer (by the mine or third-party groundwater users), draughts or climate changes there may be an impact to the long-term sustainable yield of the wellfield;
- AfriTin will need to install additional boreholes for the Phase 1 Stage II expansion to enable maintenance and to mitigate any losses in yield from the existing water supply boreholes;
- A groundwater monitoring programme has been recommended to assist AfriTin with managing their groundwater resource. Although it is recommended that boreholes be cleaned every two (2) years, any drop in yield or increased drawdown within the water supply borehole can indicate that maintenance is required;

- The groundwater monitoring will also assist AfriTin with determining if there are any changes occurring within the aquifer which may require intervention;
- AfriTin will need to investigate alternative water sources for the planned Phase 2 expansion once water demands for this phase have been confirmed. Abstracting higher yields of groundwater from the possible alternative groundwater wellfields could potentially have significant impacts to the groundwater aquifer in the region. Alternative water supply options such as piping water from the Orano Desalination plant or directly from the sea should also be considered for the Phase 2 expansion.

Recommendations

- Integrate the groundwater outcomes into the site water balance to assist with the efficient management of water resources on site and identify and minimise water losses from the system;
- Implement the monitoring, operational and maintenance requirements as outlined in the Water Management Plan (Section 6);
- Schedule borehole maintenance every 2 years unless the monitoring data (yield vs drawdown) indicates more frequent cleaning is required (Section 6.1);
- Locate or drill alternative boreholes to replace the existing boreholes if yields cannot be improved or maintained or to supplement water supply during borehole maintenance periods (after the K5 pit has been drained);
- Establish a covered water storage area nearby to the plant which contains water storage tanks with a minimum capacity of 1 week (~2 700 m^3) which can provide an emergency water source to the plant;
- AfriTin will need to amend their permitted abstraction volume to account for the required 18 m^3/hr (127 440 m^3/a) required by the plant for the Phase 1 Stage II expansion;
- Locate third-party groundwater users within a minimum 10 km radius of the mine wellfields and confirm their current abstraction requirements and planned future abstraction requirements;
- It is recommended to plan the dewatering of the K5 pit well in advance so the dewatered volumes can be used to meet the plant requirements instead of being discharged to the environment. The water in the pit has higher concentrations of calcium, magnesium, sodium, potassium chloride, sulphate, iron, manganese and electrical conductivity compared to the groundwater samples which may dictate how much of the pit water can be used during a month (if this needs to be diluted with clean or groundwater contributions). The water quality requirements of the plant will therefore need to be defined as soon as possible or the establishment of a water treatment plant could be considered;

- The numerical model must be recalibrated every 2 (two) years to incorporate the latest monitoring data as well as any changes to the water supply network or plant yield requirements. The model will be an asset to AfriTin to assess any changes which could affect the water supply for the project;
- The numerical model can be refined in future updates to simulate climate change responses to the expected rainfall volumes over the life of mine. The IPCC report indicates that drought events in Southern Africa (caused by the El Nino oscillation) are predicted to become more frequent and intense, which could affect the recharge potential to aquifers in the region.

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1. Introduction

Digby Wells Environmental (hereinafter Digby Wells) was appointed by AfriTin Mining (Namibia) (Pty) Ltd (hereinafter AfriTin) to undertake a water supply assessment for the planned expansion of production at the Uis Tin Mine, in Namibia.

Currently the pilot processing plant in operation for the Phase 1 Stage I project produces ~65 tonnes of tin concentrate per month. Water demand for the Phase 1 Stage I plant requires ~0.288 Ml/day (12 m^3/hr), which is sourced from the Uis wellfield boreholes, located in the alluvial aquifer of the Uis River. AfriTin has completed a Definitive Feasibility Study (DFS) for the expansion of its Phase 1 Stage I Pilot Processing Facility, which will occur in two phases. The Phase 1 Stage II expansion is a precursor to the long-term Phase 2 expansion, which aims to increase the mining area and develop a full-scale processing plant for the mine.

The expansion of the pilot processing plant for Phase 1 Stage II will increase production to ~100 tonnes of tin concentrate per month, which will increase the water demand of the plant to ~0.432 Ml/day (18 m^3/hr). The Phase 2 expansion plans to increase production to ~1 250 tonnes of tin concentrate per month. The water demand for the Phase 2 expansion still needs to be confirmed.

The aim of the water supply assessment is to:

- Verify the potential supply constraints of the Uis wellfield for the planned Phase 1 Stage II expansion; and
- Investigate the regional aquifer systems as an additional source of groundwater for the Phase 2 expansion.

The focus of this report is on the water supply requirements for Phase 1 Stage II and the potential constraints of the Uis wellfield.

2. Study Assumptions and Limitations

Aquifer test study limitations:

- Although boreholes were scheduled to be switched off prior to aquifer testing each of the cluster areas, observation borehole data may be influenced by abstraction in other cluster areas; and
- The community, landowners and other business operations may have boreholes in the riverbed near the Uis and Southern wellfields. Abstraction from these third-party boreholes may influence the aquifer test results.

Numerical Model Assumptions:

- The daily abstractions for third-party groundwater users are unknown and was assumed to be 200 m^3/d for the borehole at the Brandberg Rest Camp (which currently being used to supply large volumes for road construction) and 100 m^3/d for the NamClay borehole. It is understood that the abstraction from the Brandberg Rest

Camp is only expected to continue for the next 18 months, however the assumed abstraction values for both third party boreholes were modelled for the duration of the Life of Mine as a worse case scenario;

- It is assumed that these abstraction rates will continue as mentioned above for the proposed Phase 1 Stage II Life of Mine;
- The numerical model assumes abstraction boreholes will pump for a 24-hour period however the plant requirements are based on a 90% availability and 90% utilisation target equating to ~19.7- hour abstraction period per day; and
- The numerical model was calibrated with the abstractions and drawdowns currently measured and assumed for the aquifer. The Phase 1 Stage II modelled abstractions start the simulation using the current groundwater levels as reference.

3. Baseline Description

3.1. Climate

Uis is classified as a hot desert climate (BWh) based on the Köppen-Geiger classification system. The BWh classification characterises areas where evaporation and transpiration exceed precipitation with hot to exceptionally hot (over 40°C) periods of the year. Annual rainfall data was collected from four weather stations around the project area, which were measured daily between 1979 and 2014 (Figure 3-1). Rainfall typically occurs between October and April, with the months of February and March receiving the highest rainfall.

The rainfall data is relatively consistent between the weather stations with the highest variability occurring between 2011 – 2015. The annual rainfall for the project area ranges between ~2 - 592 mm, with an average of 88 mm per year (National Centers for Environmental Prediction, 2022) (Environmental Compliance Consultancy, 2021) (Environmental Compliance Consultancy, 2021). The period between 2000 – 2017 indicates a wetter period with an average rainfall of 137 mm/a compared with the previous 1979 – 1999 period which had an average rainfall of 54 mm/a. Long-term variations in rainfall will affect recharge to the groundwater aquifers, however, since 1979 there are regular peak rainfall events occurring every 2 – 4 years which will assist in buffering longer-term periods of low recharge.

3.2. Topography and Drainage

The town of Uis is located within the Uis River which is a tributary within the Ugab Catchment Area. The Uis River drains the project area in a north-westerly direction until it joins the Ugab River. The Ugab River is the main river that drains the Ugab Catchment which has an area of ~29 000 m^2. The Ugab Catchment starts in a mountainous region which receives a higher annual rainfall of between ~500 - 550 mm (Figure 3-3).

Although the town of Uis is located in the Ugab Catchment Area, the town receives water from the Omaruru River. The Omaruru River drains the Omaruru Catchment which has an area of

~11 500 m^2 and receives an annual rainfall of between ~300 - 350 mm from the mountainous region upstream.

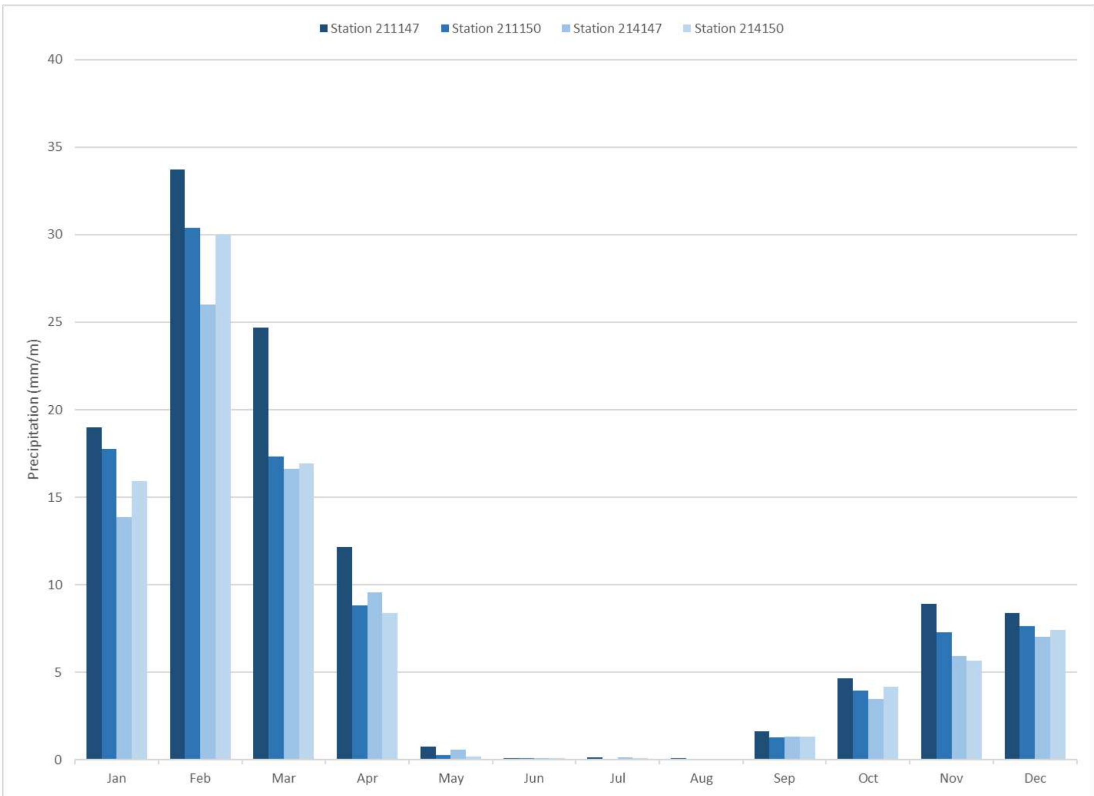

Figure 3-1: Average Monthly Rainfall per Station (1979 – 2014)

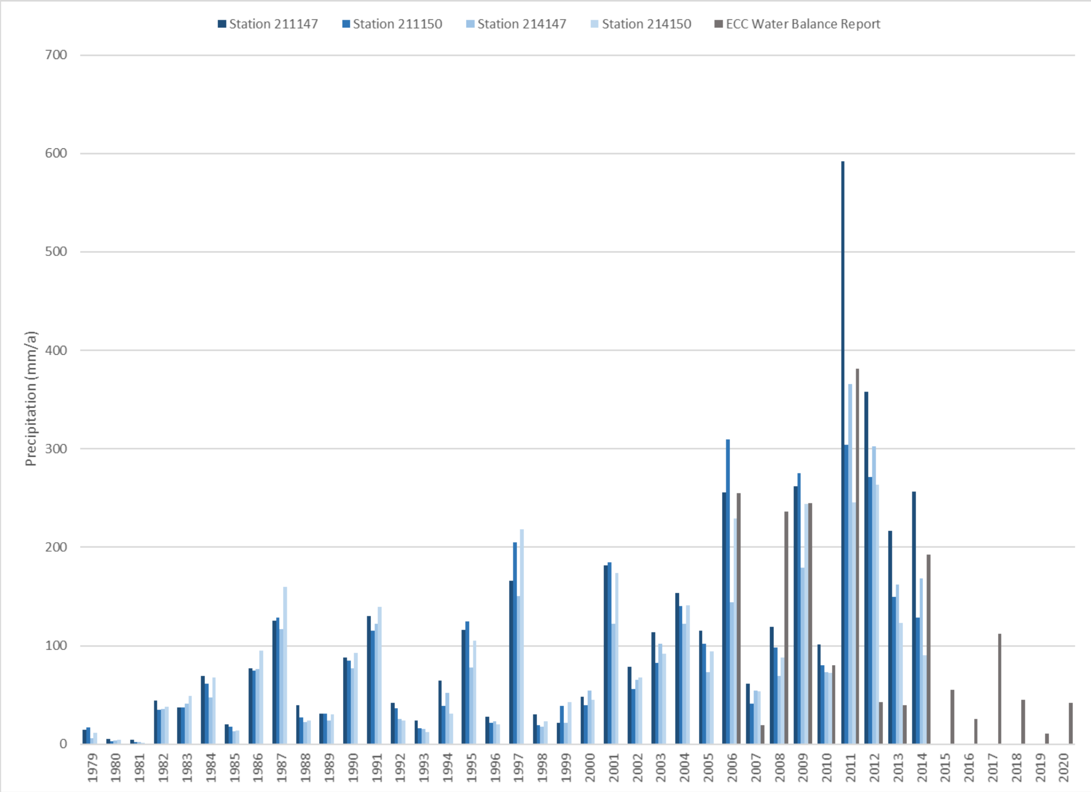

Figure 3-2: Annual Rainfall per Station (1979 – 2020)

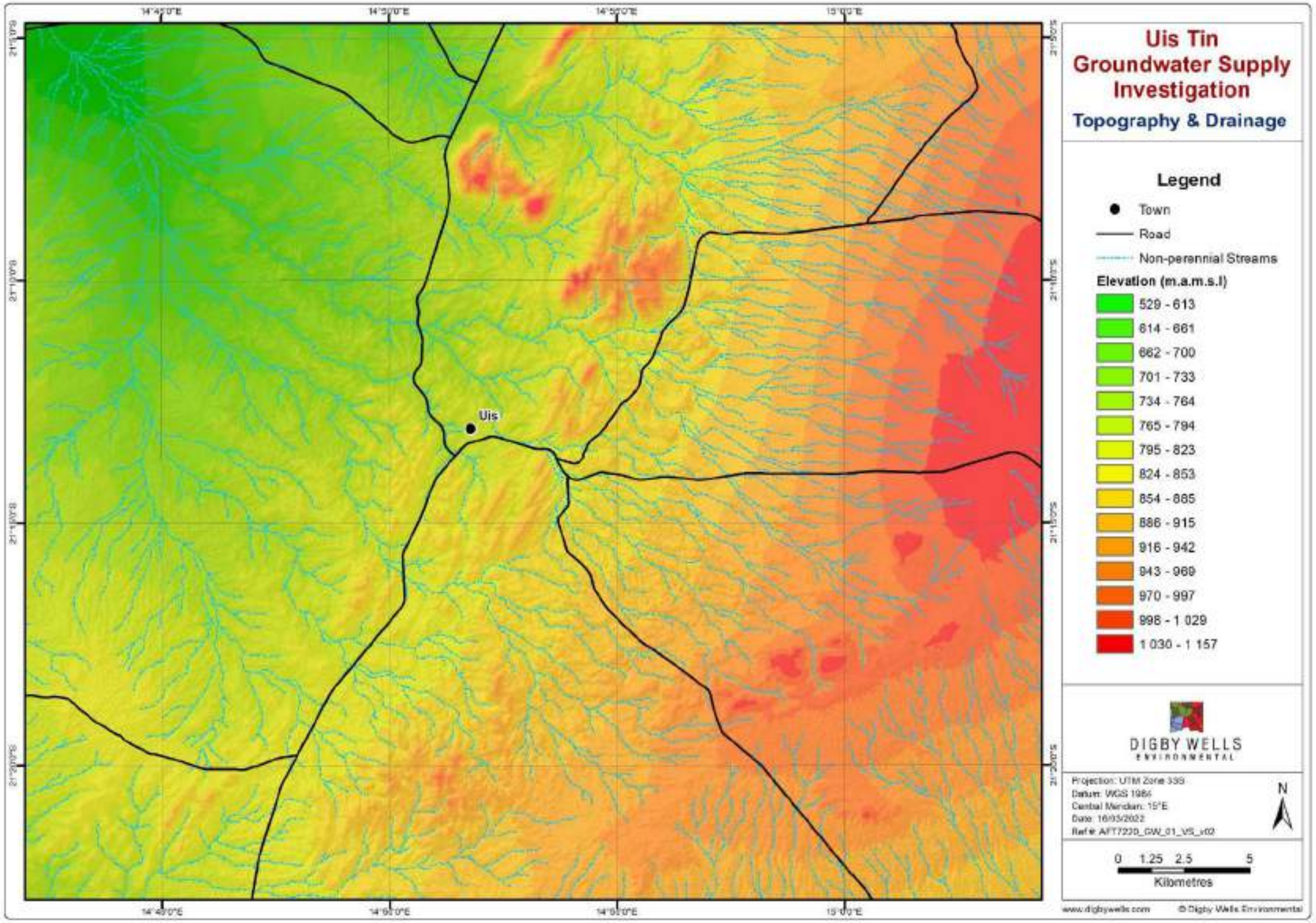

Figure 3-3: Topography and Drainage

3.3. Geology

The 1:250 000 geological map indicates that the project is located within the Southern Kaoko tectonostratigraphic zone of the Damara Orogen (Belt). The Damara Orogen is an East-North-East trending belt formed during the convergence between the Congo and Kalahari Cratons. The belt comprises of multiple fault and shear bounded zones with varying structural styles and lithologies (Gray, et al., 2008).

The regional stratigraphy around the project area (within the Southern Kaoko Zone) comprises of meta-greywacke and meta-pelite lithologies associated with the Amis Formation (Zerrissene Group), post-tectonic granites and isolated dolerite intrusions. The North-East trending Autseib Fault separates the Southern Kaoko Zone (in the North) from the Northern Central tectonostratigraphic zone (to the South) which comprises of mica schists and marbles associated with the Kuiseb and Karibib Formations of the Swakop Group (Figure 3-4). Mineralisation is hosted within granitic pegmatites. The pegmatites intruded into the Amis Formation post-tectonically and are associated with minor faulting (AfriTin Mining, 2017). Boreholes which intersect fractures associated with the pegmatites can be high yielding.

In 2018, eight (8) water supply boreholes were drilled in river channels around the mine (Figure 3-7). The river channels had alluvial gravels between 2 -13 mbgl, with an average of 6 mbgl. Below the gravels the geological logs indicate that quartzite, schist and pegmatite lithologies were intersected (BVW Groundwater Consulting Services, 2019). These lithologies are weathered to depths of between 14 – 50 mbgl (with an average of 25 mbgl) (Figure 3-6). Images of the core from exploration holes indicates that the core samples are highly broken and weathered between 2 – 19 mbgl. Below the weathered zone the core becomes more competent except at fracture and/or faulted zones.

The geological logs for the water supply boreholes indicate fractures were intersected between 27 – 111 mbgl, with an average depth of 46 mbgl (Figure 3-5). Although most boreholes indicate low yields for fractures below 50 mbgl, BH8 did intersect a high yielding fracture at a depth of 85 mbgl (with an estimate yield of 20 m^3/hr).

Table 3-1: Regional Stratigraphy

Supergroup	Group	Formation	Lithology	Map Code
			Quaternary sediments	Qs
			Granite (coarse grained)	OgSAs
			Granite (fine-medium grained)	єggp
			Granite (fine-medium grained, leucogranite)	єgls
			Granite (medium-course grained, porphyritic)	NgSAp
Damara Sequence	Swakop	Kuiseb	Mica schist	NKs
		Karibib	Marbles	NKb
	Zerrissene	Amis	Meta-greywacke and meta-pelites, minor carbonate and quartz-wacke	NAm

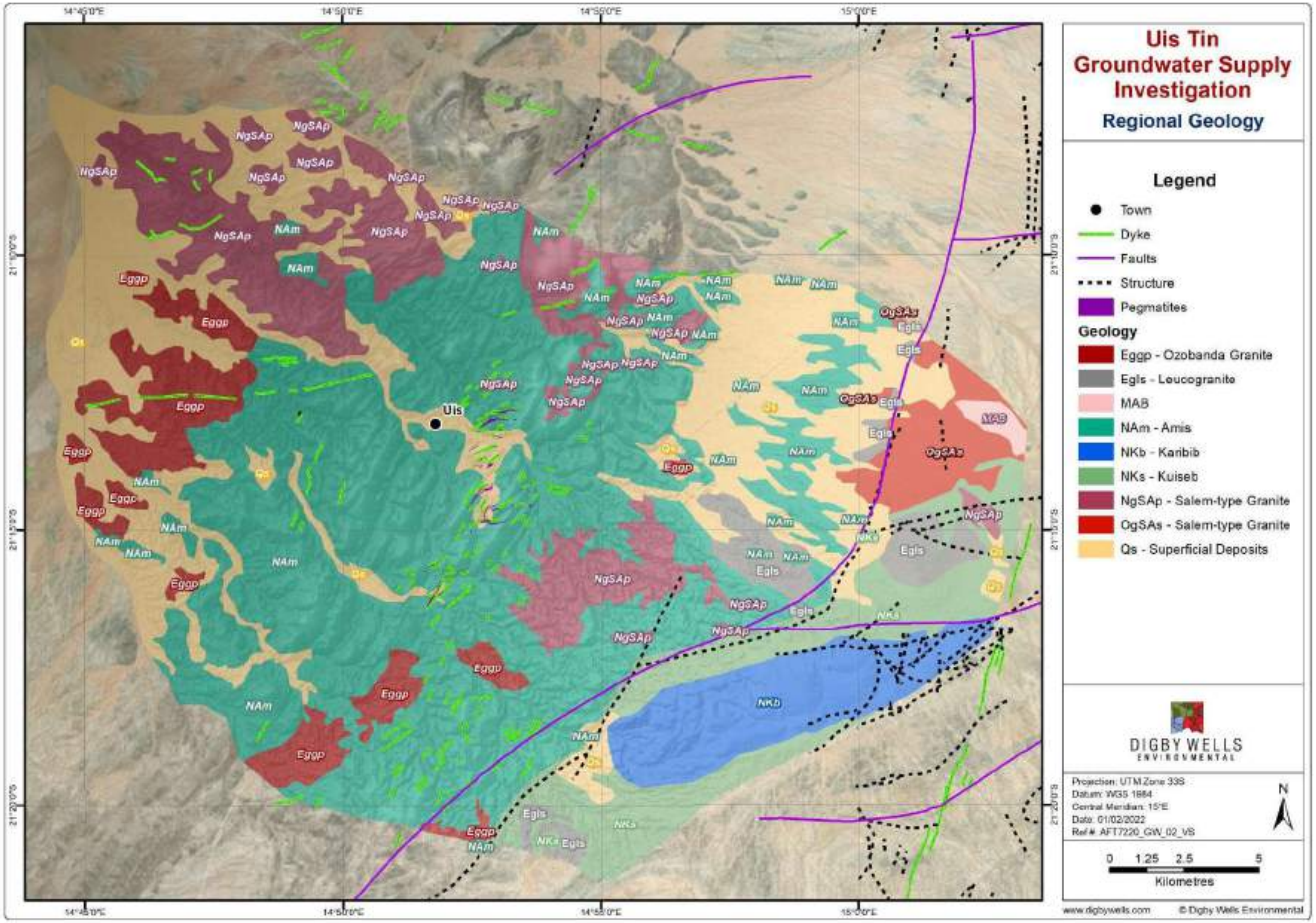

Figure 3-4: Regional Geology

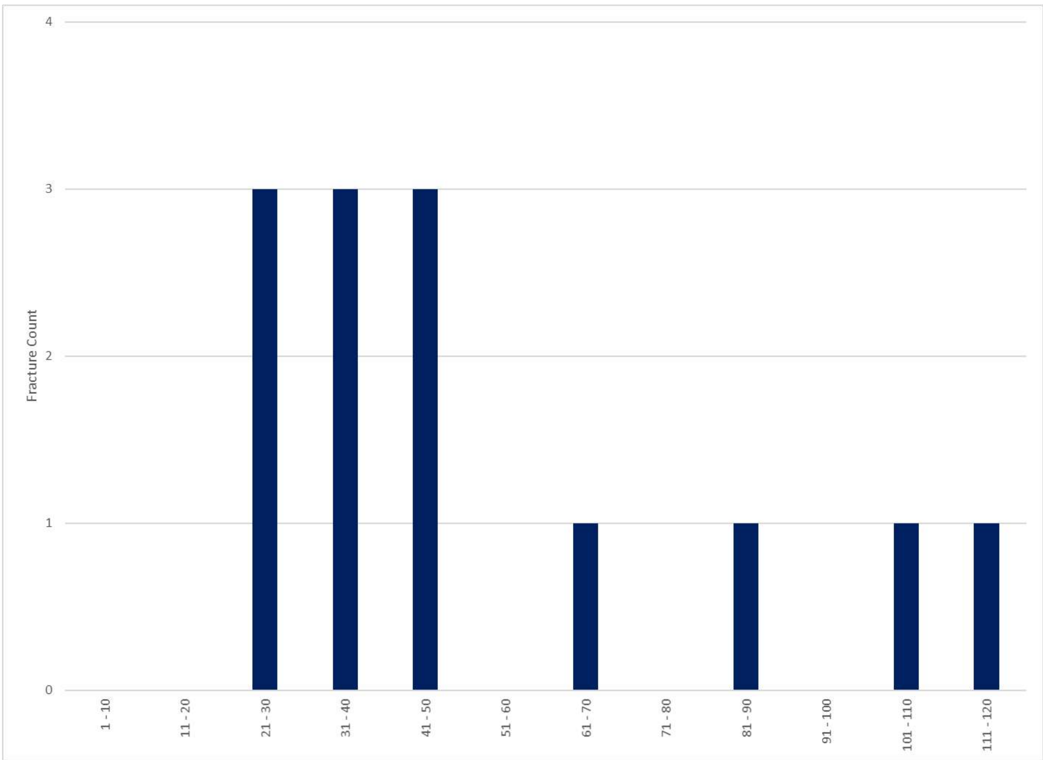

Figure 3-5: Fracture Frequency in Water Supply Boreholes

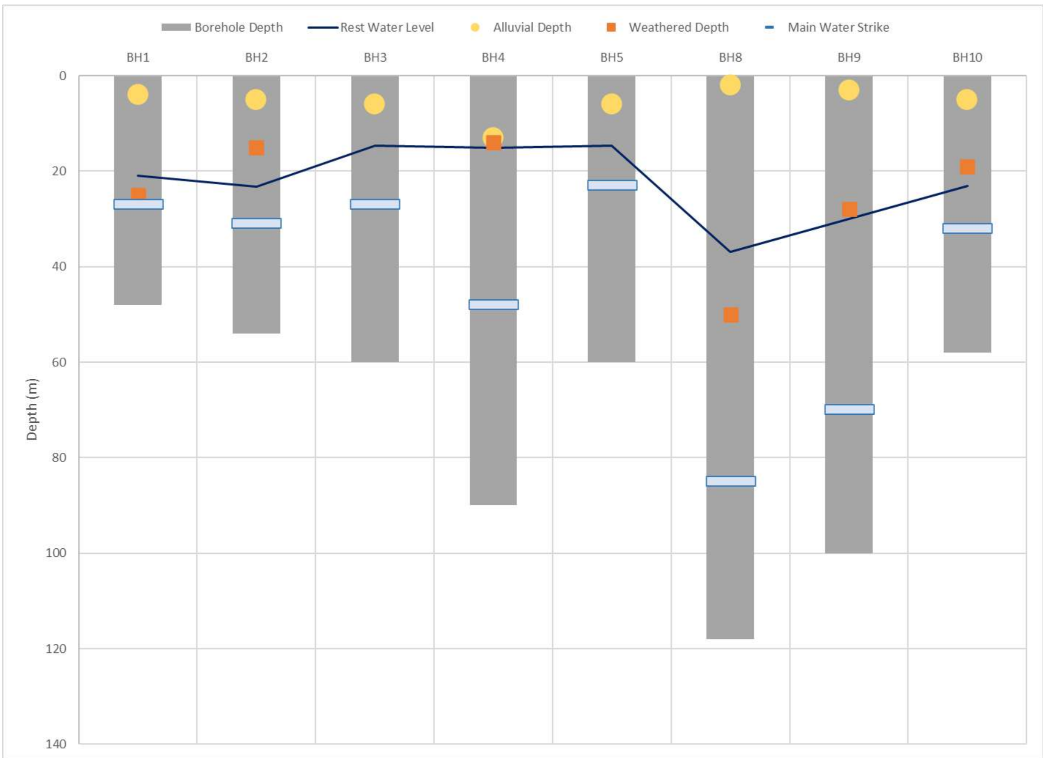

Figure 3-6: Water Supply Boreholes[1]

[1] Lithological logs for BH6, BH11 and BH12 were not available.

3.4. Hydrogeology

Uis is located within the Brandberg – Waterberg hydrogeological region of Namibia bordering with the Northern Namib and Kaokoveld hydrogeological region immediately to the Northwest (Ministry of Agriculture, Water and Rural Development, 2011). Boreholes have been established in the Uis River as far back as 1926 (approximately 3 locations), with historical mining operations drilling an additional 16 boreholes between 1950 and 1960. AfriTin currently have 11 water supply boreholes around their project area (Figure 3-7), 8 of which were drilled in 2018. Seven of the water supply boreholes are located in the Uis wellfield and the remaining four boreholes are in the Southern wellfield.

3.4.1. Groundwater Levels

Historical water level records are limited but indicate that water levels in the Uis River were approximately 16 mbgl in 1926 which is comparable to the water levels currently measured in the Southern wellfield. The boreholes drilled in the Uis River during the 1950's indicate an initial water level of between 18 – 23 mbgl. Historical records indicate that abstraction from these boreholes ranged between 2 – 8 m^3/hr. During the five-year monitoring period in the 1950's the groundwater levels dropped to between 31 – 37 mbgl (Figure 3-8). Abstraction would reduce the groundwater levels during this period however the influence of low recharge (or rainfall) may also be a contributing factor but cannot be confirmed.

The current Uis (BH1, BH2, BH8, BH9, BH10) and Southern (BH3, BH4, BH5, BH6) wellfield boreholes were aquifer tested in July 2018. The July 2018 rest groundwater levels (RWL) ranged between 21.0 – 36.9 mbgl, with an average of 26.8 mbgl in the Uis wellfield. The 2018 groundwater levels in the Southern wellfield were shallower ranging between 14.6 – 16.5 mbgl, with an average of 15.2 mbgl.

AfriTin commenced monitoring groundwater levels in six of the Uis wellfield boreholes in September 2020. The monitoring data shows that the groundwater levels in all the monitored boreholes have declined by between 2.4 – 7.8 m (Table 3-2 and Figure 3-9). The largest drop in groundwater levels is within BH2, BH8 and BH10. Although no abstraction has taken place from BH9 and BH12, and a minimal volume has been abstracted from BH2, the groundwater levels in these boreholes show a general decline in levels indicating the aquifer is either being affected by the current abstraction and/or by limited recharge to the aquifer. Abstraction volumes range between 237 m^3/month and 12 224 m^3/month, with an average of 5 534 m^3/month (Figure 3-10).

The Southern wellfield boreholes are not equipped and are not currently in use. Recent water level measurements indicate that the groundwater level in the Southern wellfield have declined by between 1.3 – 1.6 m (Table 3-2 and Figure 3-9). As no abstraction is taking place from these wells, the decline in groundwater levels is associated with low recharge to the catchment or external third-party groundwater use in the catchment.

Between 19 January and 15 February 2022, the site has received approximately 90 mm of rainfall, which has resulted in a rise in groundwater levels of between 0.8 – 8.3 m (Table 3-2).

Table 3-2: Water Level Summary Table

Borehole	Jul-18	Sep-20	Apr-21	Dec-21	Jan-22	Feb-22	Mar-22[2]	Change in Water Level Prior to Rainfall Event[3]	Change in Water Level After Rainfall Event[4]	Total Volume Abstracted to Date
BH1	21.01	21.43	-	23.85	-	23.10	23.20	-2.42	0.75	10 644
BH2	23.18	25.78	-	29.95	-	29.00	31.00	-4.17	0.95	386
BH3	14.71	-	-	-	15.98	-	-	-1.27	-	-
BH4	15.08	-	-	-	16.66	-	-	-1.58	-	-
BH6	16.51	-	-	-	17.88	-	-	-1.37	-	-
BH8	36.90	-	36.04	40.60	-	35.20	35.20	-4.56	5.40	21 011
BH9	29.98	30.75	-	31.50	33.74	29.20	28.50	-2.99	2.30	-
BH10	23.03	26.82	-	34.60	-	32.90	32.70	-7.78	1.70	40 985
BH11	-	-	-	-	41.25	33.00	32.74	-	8.25	-
BH12	-	28.65	-	31.55	31.90	29.10	28.90	-3.25	2.45	-

[2] Groundwater level as at 04/03/2022.
[3] Change in groundwater level prior to rainfall calculated with Jul-2018/Sept-2020 water levels compared to Dec-2021/Jan-2022 water levels.
[4] Change in groundwater level after rainfall calculated with Dec-2021 water levels compared to Feb-2022 water levels. Current groundwater levels for March are similar to Feb and therefore comparison has not been updated to March groundwater levels.

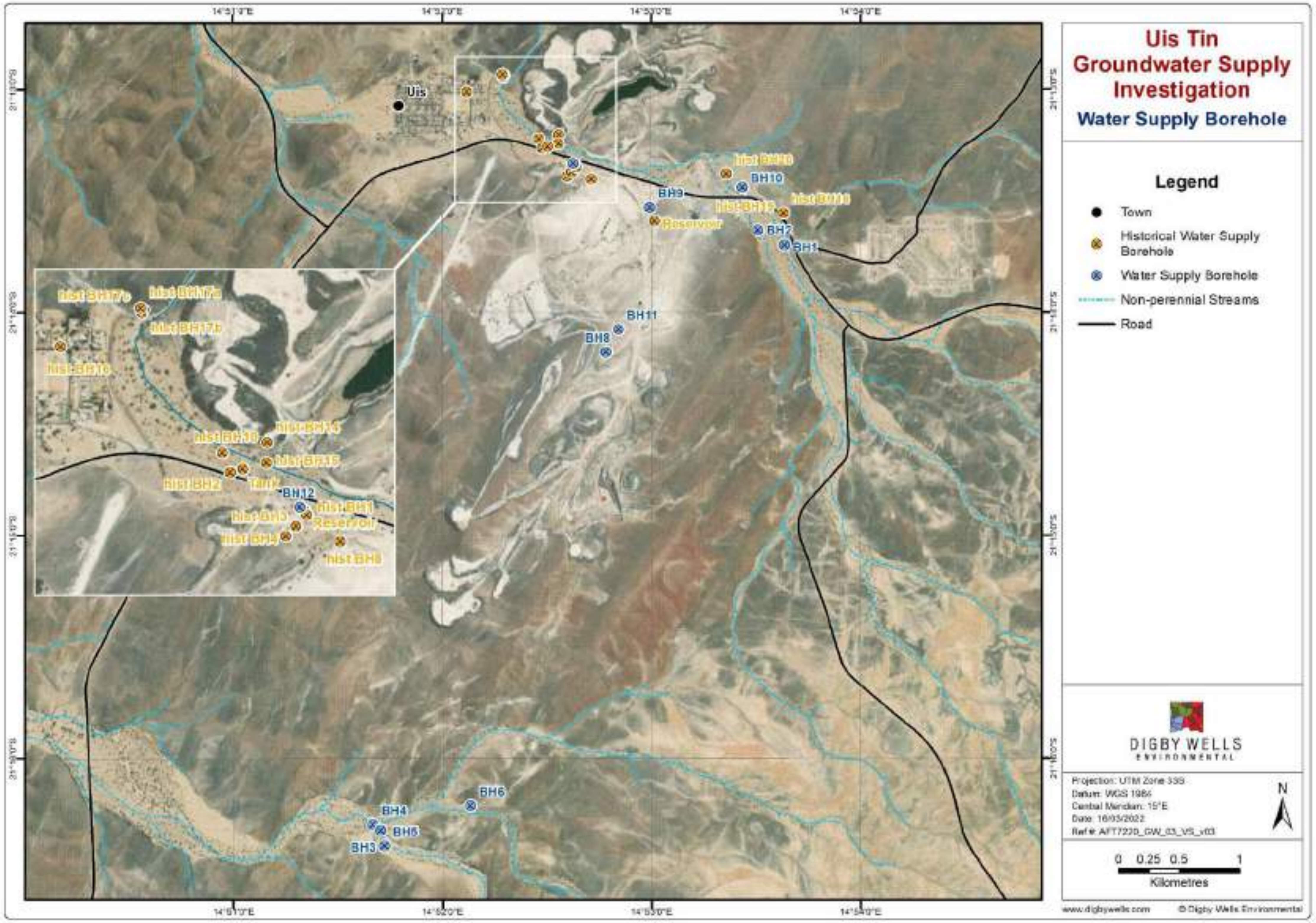

Figure 3-7: Water Supply Borehole Locations

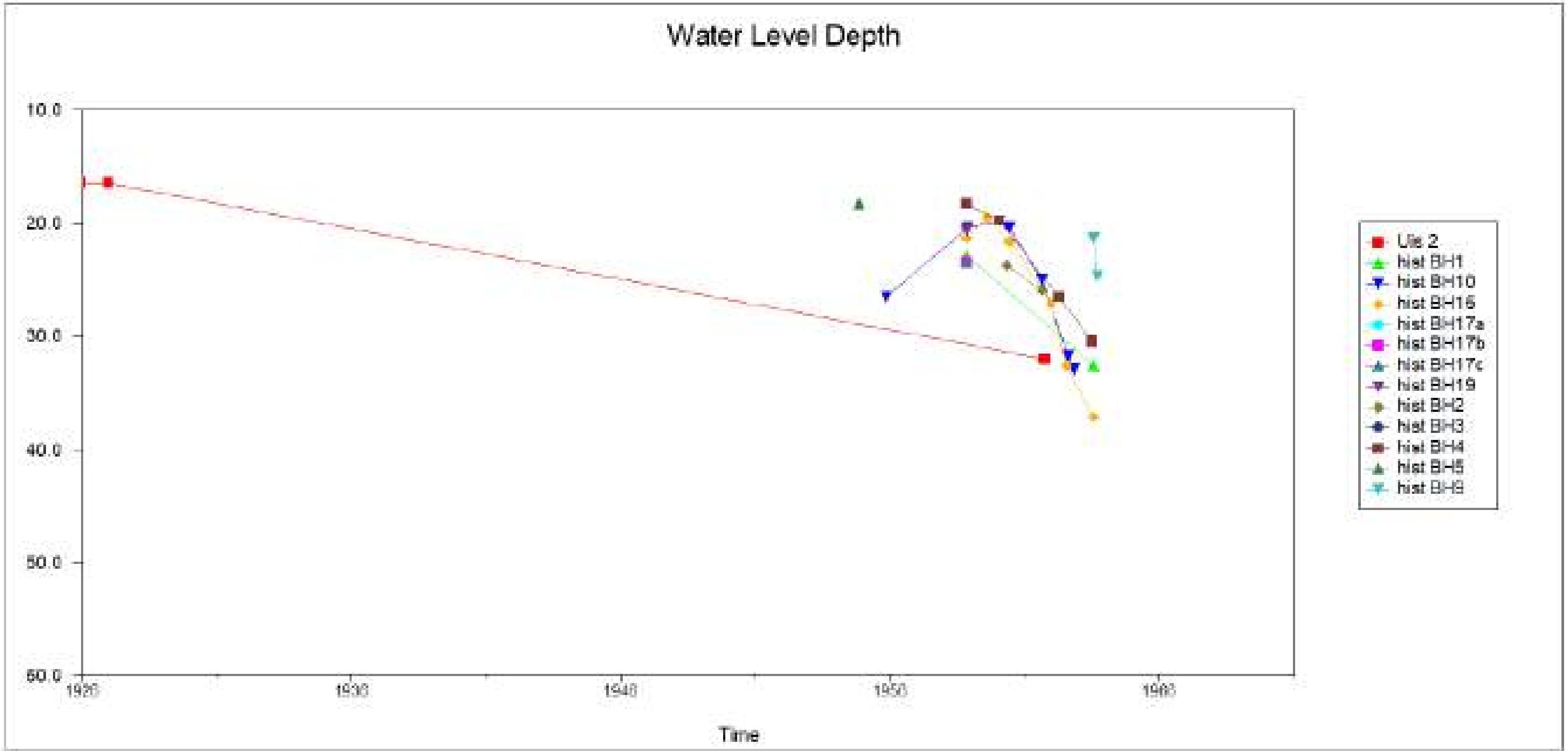

Figure 3-8: Groundwater Levels in Historical Water Supply Boreholes

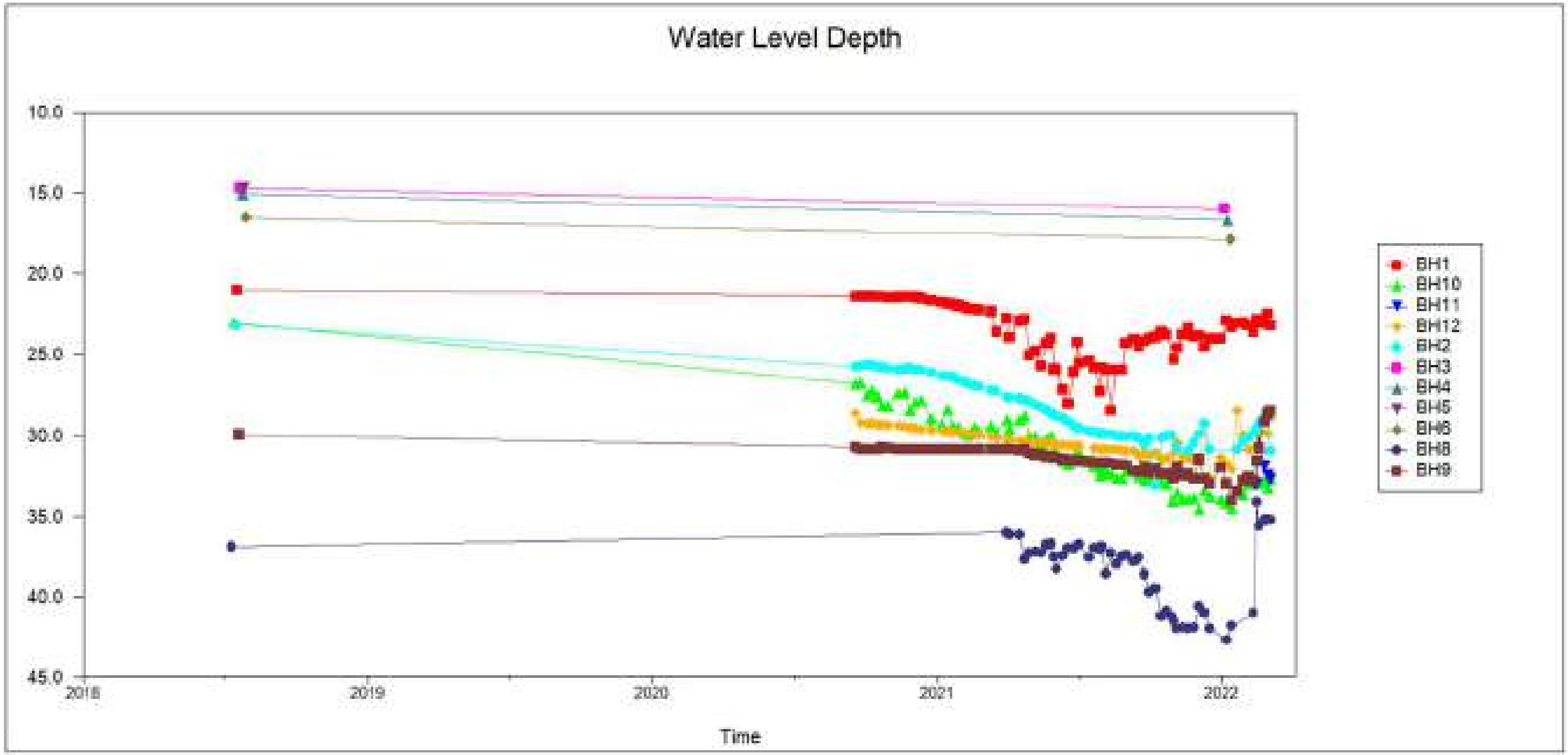

Figure 3-9: Groundwater Levels in Current Water Supply Boreholes

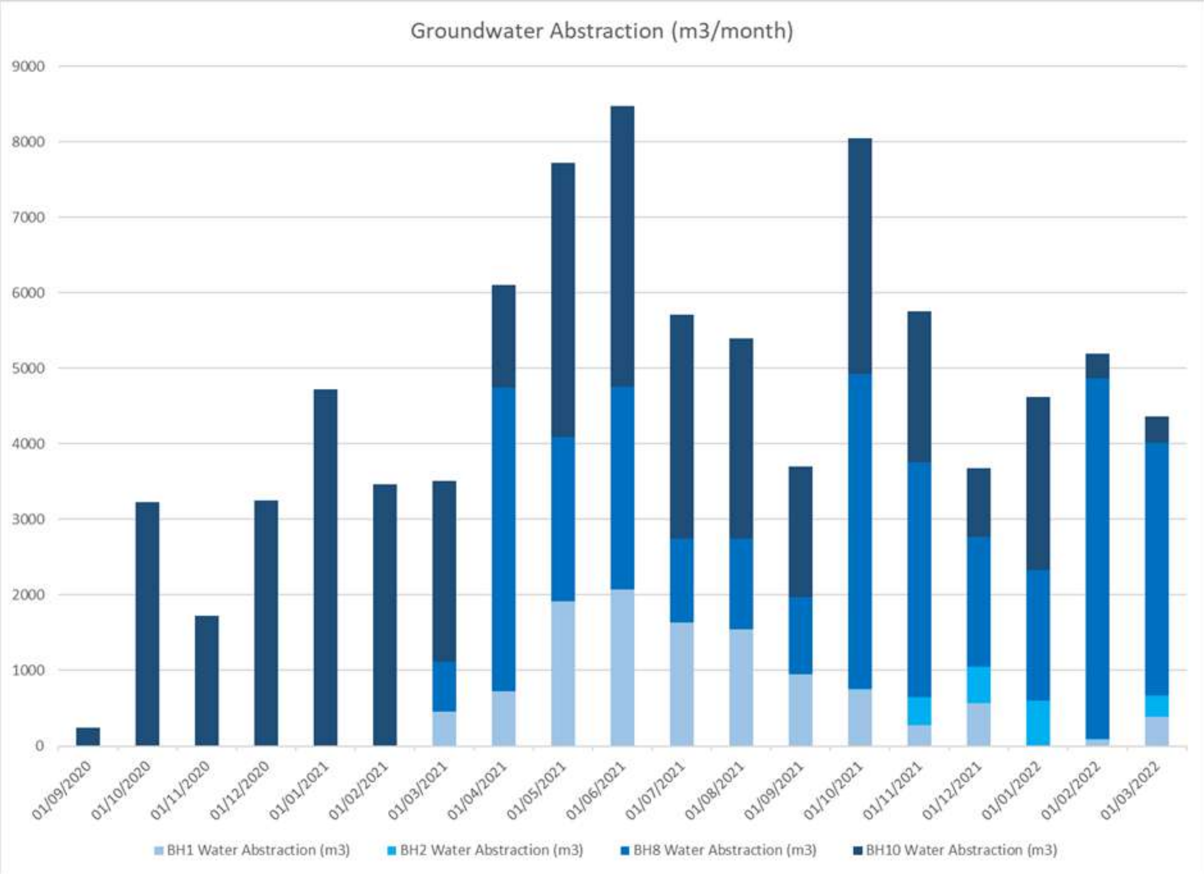

Figure 3-10: Groundwater Abstraction Volumes

3.4.2. Groundwater Quality

The laboratory certificates are provided in Appendix B.

3.4.2.1. Hydrochemistry

The chemical composition of natural waters can be interpreted using Piper, Expanded Durov and STIFF Diagrams. The Piper Diagram (Figure 3-11) is useful for identifying different types of groundwater facies which can be improved upon with the Expanded Durov Diagram (Figure 3-12). The Expanded Durov Diagram is useful for interpreting hydrochemical processes such as ion exchange and/or simple dissolution. The STIFF Diagrams (Figure 3-13) are useful to make visual comparisons between samples with different sources.

- The Piper and Expanded Durov Diagrams indicate that the samples can be differentiated into four (4) distinctive groups:
  - A sodium-chloride water type typically indicates groundwater with a long residence time or stagnant (slow moving) groundwater with little to no recharge which typically indicates the end of the hydrogeological cycle or that salts (sodium-chloride) have affected the source. This group is represented by

samples for BH3, BH6, BH8, BH10, BH11 and BH12 and will be referred to as the main sodium-chloride water type group;

    - Within the sodium-chloride water type the BH1 and BH9 samples form a separate subgroup on the Piper Diagram with a slightly higher sodium and alkalinity level compared to the other boreholes within this group;
    - The K5 pit sample indicates a sodium-chloride water type and plots near to the main sodium-chloride water type group however this sample has a higher sodium concentration comparable to the BH1 and BH9 subgrouping;

  - The magnesium-chloride water type typically indicates a mix of different water types or contamination by chlorides. This group is represented by the samples for BH2 and BH4 and although they have a different dominant cation they plot with the main sodium-chloride water type group;

- The STIFF Diagrams indicate BH1 and BH9 have a slightly different signature compared to the other boreholes. BH 1 and BH9 signatures show a smaller influence of sulphate in the signature compared with the other boreholes, however the remaining anions and the cations are comparable to the other signature; and
- The K5 pit sample has a similar signature to the groundwater samples but at significantly higher concentrations.

The project area is characterised by fractured igneous and metamorphic rock aquifers which are overlain by shallow alluvial aquifers in river channels. The aquifers receive low recharge (less than 0.7% MAP or 0.61 mm/a), and the hydrochemistry is therefore representative of groundwater with a long residence time or slow-moving groundwater allowing rock interaction processes to occur over long periods.

The available logs for the water supply boreholes indicate that quartzite (and in some instances schist) was intersected by the boreholes. The slight differences between the water types and signatures may be representative of different rock interactions and/or mixing of different waters during abstraction.

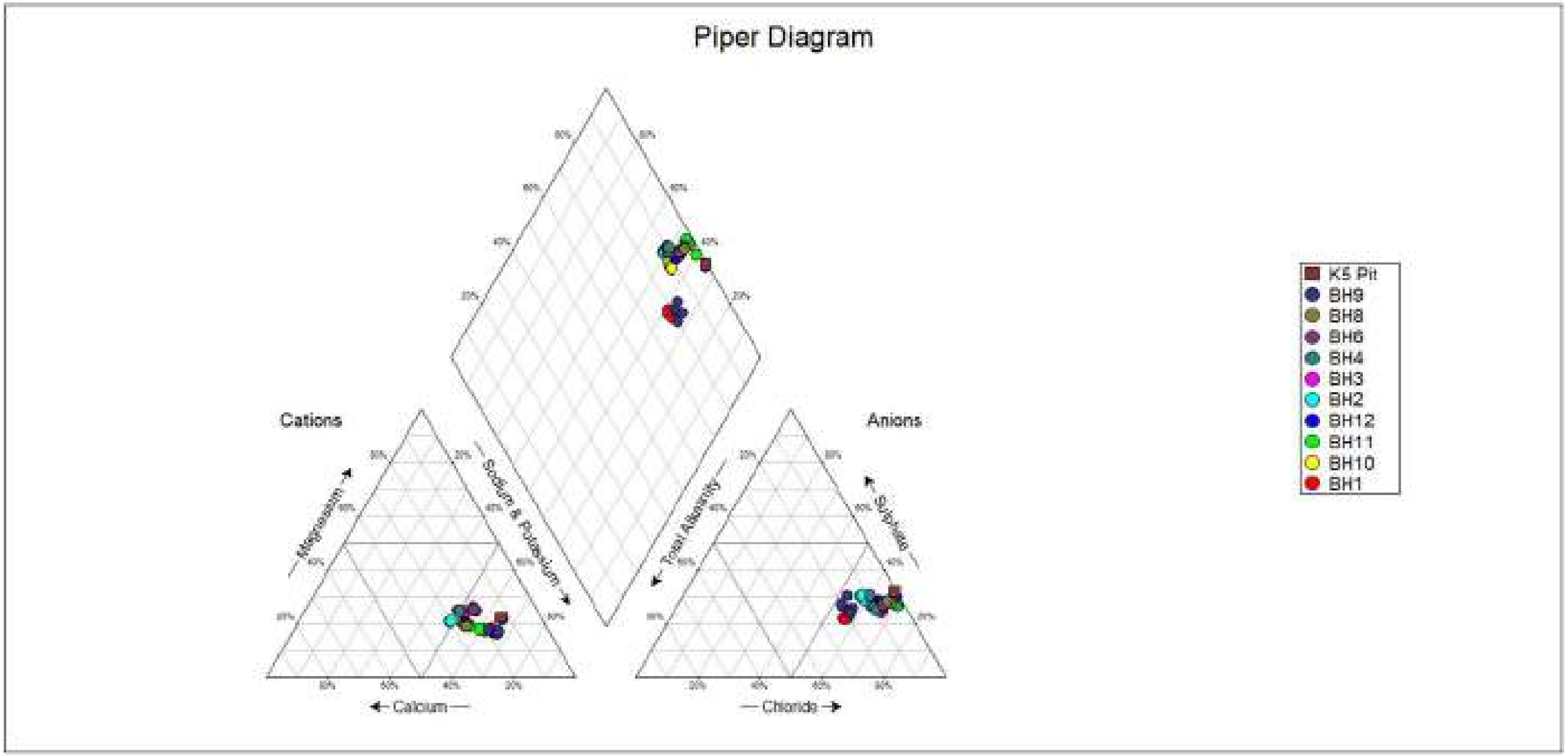

Figure 3-11: Piper Diagram

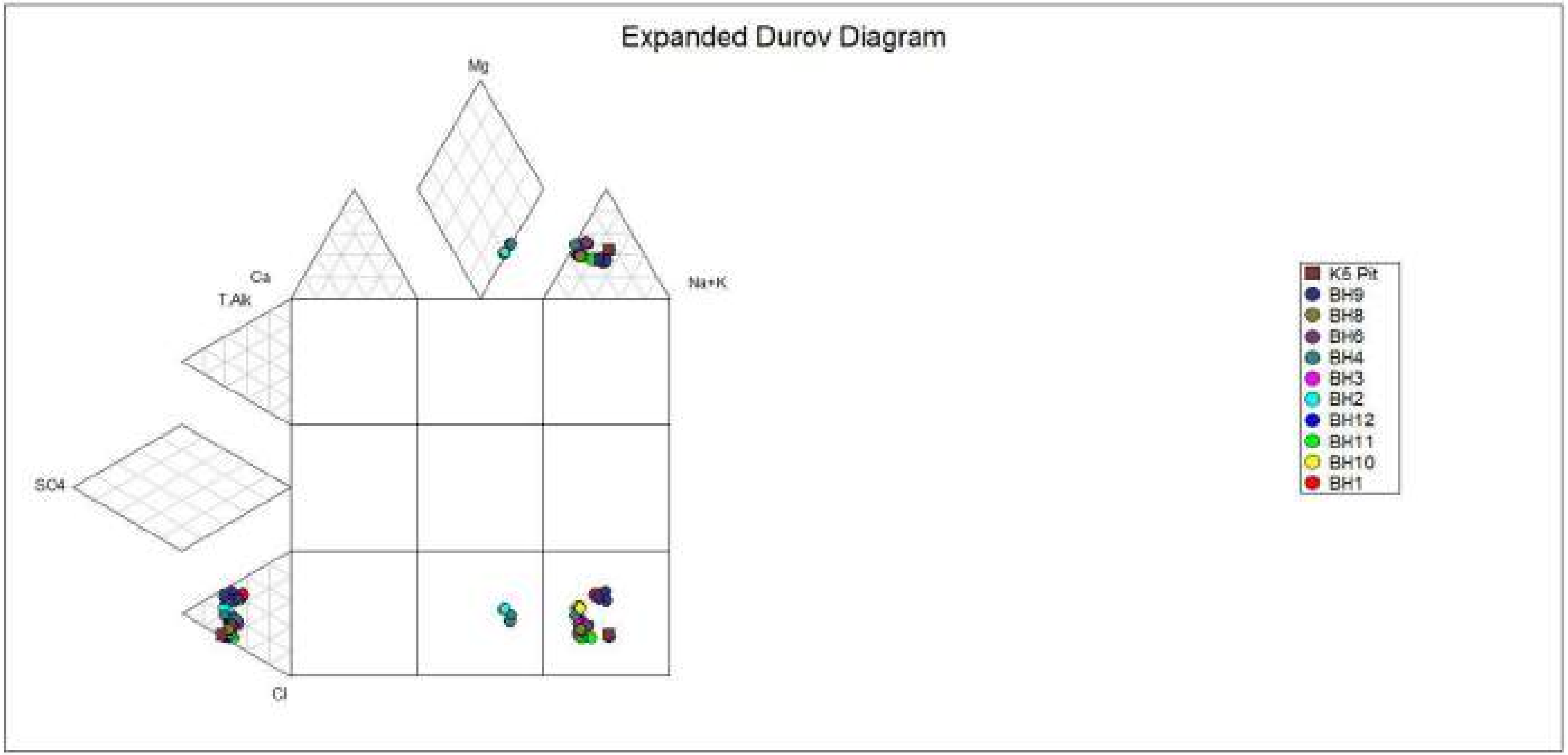

Figure 3-12: Expanded Durov

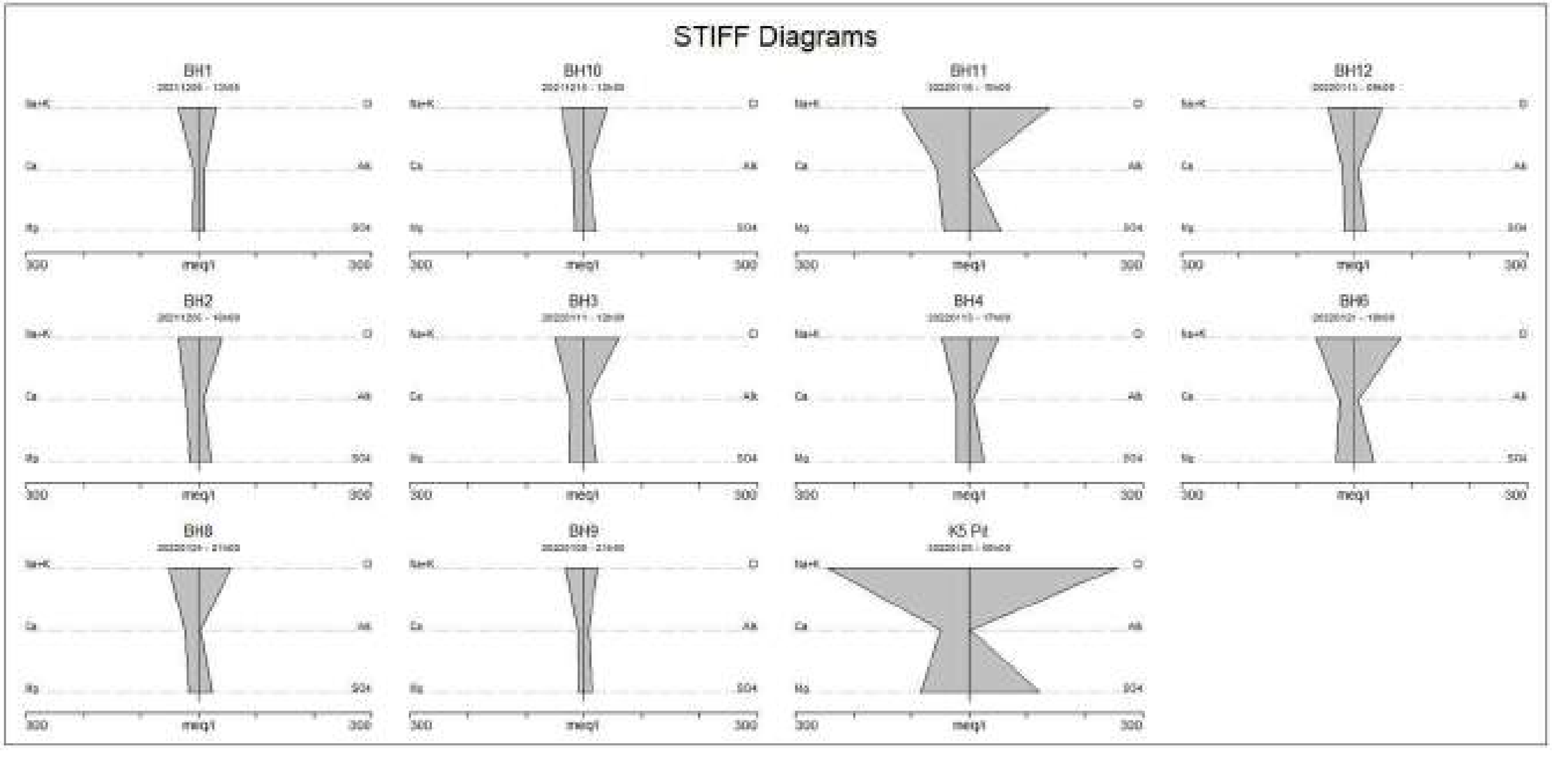

Figure 3-13: STIFF Diagrams

3.4.2.2. Quality

There are currently no water quality guideline requirements for the process water used by Uis Tin Mine processing plant. The groundwater quality has therefore been compared to the guidelines for safe drinking water as described by the Namibia Water Corporation (Namibia Water Corporation, 1998) (Department of Water Affairs (Namibia), 1988). The drinking water guideline limits provide a basis of comparison between samples with regards to elevated concentrations. The concentration of and limits for the aesthetic, physical and inorganic determinants define the group into which water will be classified. The water quality has been grouped into 4 quality classes:

- Group A: Water with an excellent quality;
- Group B: Water with acceptable quality;
- Group C: Water with low health risk; and
- Group D: Water with a high health risk, or water unsuitable for human consumption.

Water should ideally be of excellent quality (Group A) or acceptable quality (Group B), however in practice many of the determinants may fall outside the limits for these groups. If water is classified as having a low health risk (Group C), attention should be given to this problem, although the situation is often not critical as yet. If water is classified as having a higher health risk (Group D), urgent and immediate attention should be given to this matter.

The overall quality group, into which water is classified, is determined by the constituent that complies the least with the guidelines for the quality of drinking water. The groundwater quality, in each borehole, compared to the guidelines for drinking-water quality is summarised in Table 3-3.

The overall quality group for all the water supply boreholes and the K5 Pit is Group D. This is due to the elevated concentrations of chloride, sulphate, sodium and to a less extent the slightly elevated calcium, magnesium and nitrate concentrations. Subsequently the electrical conductivity is also elevated in all samples. The observed elevated concentrations are geogenic (naturally occurring), likely as a consequence of the geochemical characteristics of the parent rocks and rock-water interaction.

Five (5) samples were collected during the 48-hour CDT aquifer tests which allows for trend analysis. Time-series trends are provided for pH and electrical conductivity (Figure 3-14), chloride and sulphate (Figure 3-15), and magnesium and sodium (Figure 3-16). There are minor fluctuations between samples for majority of the boreholes, however BH8 and BH11 do show a slight change in concentrations between the samples.

Initially BH8 and BH11 indicated high concentrations for major anions, cations and electrical conductivity which decreased and stabilized after the third sample. BH8 has four (4) fractures at depths of 50 m, 85 m, 106 m and 111 m. The fracture at 85 m is the highest yielding fracture (with an estimate of >20 m^3/hr) with the other fractures noted as being small. The change in water quality could initially indicate contributions from the smaller fracture until this is depleted and the larger deeper fracture provides more water to the borehole. The borehole log for BH11 is not available but based on proximity to BH8, BH11 may have a similar fracture set.

An anomalous spike is present for the fourth sample in BH12, which has water quality results similar to the K5 pit water sample. It was confirmed with Analytical Laboratories that the analysis was correct for this sample. It is unlikely that water from the pit would have been drawn into BH12 as the fifth sample would have shown a change in water quality as well, and therefore it is concluded that there may have been a sampling error for this sample and should therefore be disregarded

3.4.2.3. Corrosion

The equilibrium saturation point of water for calcium carbonate and other salts is described by various indices which provide an indication of the scale-forming or corrosive potential of the water. If water is supersaturated, it is scale forming, whereas if it is undersaturated, it is non-scale forming or corrosive. Corrosion can be a problem in distribution systems and appliances with metallic structures in contact with water.

The following corrosion/scaling indices were calculated:

- Langelier index: A positive Langelier index indicates scale-forming tendency and a negative Langelier index indicates a scale-dissolving tendency, with the possibility of corrosion.
- Ryznar index: A value less than 6.5 indicate scale-forming tendency and a value greater than 6.5 corrosive tendency.
- Corrosion ratio: A ratio less than 0.1 indicates general freedom from corrosion in neutral to slightly alkaline oxygenated waters. Higher ratios indicate a tendency towards progressive corrosion, that is, aggressive waters.

A summary of the corrosion/scaling indices is shown in Table 3-4. The groundwater observed in all the water supply boreholes and the K5 Pit sample is scale-forming and has progressive corrosion tendencies.

Table 3-3: Groundwater Quality of Water Supply Boreholes Compared to the Guidelines for Safe Drinking Water

Constituents[5]	Guidelines For Human Consumption				BH1	BH1	BH1	BH1	BH1	BH2	BH2	BH2	BH2	BH2	BH10	BH10	BH10	BH10	BH10
	Group A	Group B	Group C	Group D	07/12/21 08:56	07/12/21 19:00	08/12/21 05:03	08/12/21 15:01	19/12/21 13:55	03/12/21 15:59	04/12/21 06:42	04/12/21 16:10	05/12/21 12:35	05/12/21 16:00	13/12/21 11:00	13/12/21 19:00	14/12/21 05:00	14/12/21 20:00	15/12/21 12:00
pH	6-9	5.5-9.5	4-11	<4->11	7.5	7.5	7.2	7.1	7.1	7.1	6.7	6.9	7	6.97	7	7	7.1	6.9	6.9
Electrical Conductivity mS/m	150	300	400	>400	535	530	532	531	536	651	652	652	654	657	658	664	668	670	670
Total Dissolved Solids[6]	-	-	-	-	3,295	3,213	3,210	3,181	3,190	4,126	4,195	4,096	4,120	4,148	4,100	4,164	4,164	4,241	4,386
Turbidity	1	5	10	>10	1.3	0.35	0.95	0.29	0.62	26	0.3	0.55	0.35	0.6	0.5	0.7	0.75	0.4	0.4
Calcium as Ca	150	200	400	>400	199	229	230	228	198	434	426	434	428	427	377	376	361	368	369
Magnesium as Mg	70	100	200	>200	117	120	121	118	122	180	182	178	180	183	176	174	178	173	175
Sodium as Na	100	400	800	>800	799	778	761	776	791	791	778	790	787	790	832	866	874	894	892
Potassium as K	200	400	800	>800	32	31	31	30	31	32	32	31	31	31	34	33	34	34	34
Total Alkalinity as $CaCO_3$	-	-	-	-	525	550	545	550	550	395	395	400	410	405	410	420	420	435	425
Total Alkalinity as $CaCO_3$	-	-	-	-	525	550	545	550	550	395	395	400	410	405	410	420	420	435	425
Chloride as Cl	250	600	1200	>1200	1,060	1,037	1,037	991	1,037	1,383	1,452	1,406	1,429	1,406	1,383	1,360	1,383	1,406	1,429
Sulphate as SO_4	200	600	1200	>1200	561	531	550	528	534	992	1,002	932	942	1,008	948	981	964	1,002	1,002
Nitrate as N	10	20	40	>40	47	35	34	40	33	17	19	19	17	13	23	27	26	23	52
Nitrite as N	-	-	-	-	0.01	0.01	0.02	0.02	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride as F	1.5	2	3	>3	1.8	1.9	1.9	2	1.9	1.3	1.3	1.2	1.2	1.2	1.5	1.6	1.6	1.6	1.6
Iron as Fe	0.1	1	2	>2	0.01	0.01	<0.01	0.01	0.01	2.2	0.01	0.01	0.01	0.01	<0.01	0.01	0.01	0.01	0.01
Manganese as Mn	0.05	1	2	>2	<0.01	0.01	0.01	0	0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia as N	1	2	4	>4	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Hardness as $CaCO_3$	300	650	1300	>1300	979	1,066	1,073	1,055	997	1,825	1,813	1,817	1,810	1,820	1,666	1,655	1,634	1,631	1,642
Ca-Hardness as $CaCO_3$	375	500	1000	>1000	497	572	574	569	494	1,084	1,064	1,084	1,069	1,066	941	939	901	919	921
Mg-Hardness as $CaCO_3$	290	420	840	>840	482	494	498	486	502	741	749	733	741	754	725	717	733	712	721
Overall Quality Group[7]	-	-	-	-	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**

[5] All constituents are in mg/l unless otherwise stated.
[6] Calculated value
[7] The overall quality group into which a water is classified, is determined by the determinant that complies the least with the guidelines for the quality of drinking water.

Table 3-3: Groundwater Quality of Water Supply Boreholes Compared to the Guidelines for Safe Drinking Water

Constituents[8]	Guidelines For Human Consumption				BH3	BH3	BH3	BH3	BH3	BH4	BH4	BH4	BH4	BH4	BH6	BH6	BH6	BH6	BH6
	Group A	Group B	Group C	Group D	06/01/2022 19:50	07/01/2022 18:00	09/01/2022 18:00	10/01/2022 18:00	11/01/2022 12:00	11/01/2022 17:00	12/01/2022 05:00	12/01/2022 17:00	13/01/2022 05:10	13/01/2022 17:00	15/01/2022 13:00	16/01/2022 00:40	16/01/2022 14:00	21/01/2022 06:00	21/01/2022 18:00
pH	6-9	5.5-9.5	4-11	<4->11	7	7	7	7	6.92	6.9	6.9	7	7	7	6.9	7	7	6.9	6.9
Electrical Conductivity mS/m	150	300	400	>400	899	888	884	881	883	793	798	798	803	805	1,152	1,141	1,178	1,167	1,147
Total Dissolved Solids[9]	-	-	-	-	5,505	5,416	5,434	5,447	5,408	4,651	4,719	4,843	4,917	5,074	7,211	7,048	7,106	7,387	7,132
Turbidity	1	5	10	>10	0.35	0.3	0.3	0.55	0.4	0.2	0.25	0.25	0.75	0.3	0.35	0.2	0.6	0.35	0.2
Calcium as Ca	150	200	400	>400	459	467	465	463	459	440	462	455	457	462	492	485	490	517	493
Magnesium as Mg	70	100	200	>200	291	294	294	294	295	262	272	270	273	280	377	369	386	383	378
Sodium as Na	100	400	800	>800	1,160	1,159	1,149	1,154	1,147	994	1,002	976	993	1,030	1,526	1,466	1,465	1,503	1,482
Potassium as K	200	400	800	>800	55	53	54	53	55	46	47	47	48	48	84	81	84	82	81
Total Alkalinity as $CaCO_3$	-	-	-	-	410	400	400	400	395	400	380	385	385	380	410	410	405	405	405
Chloride as Cl	250	600	1200	>1200	2,166	2,120	2,143	2,166	2,143	1,659	1,728	1,866	1,889	1,774	2,857	2,834	2,857	2,949	2,857
Sulphate as SO_4	200	600	1200	>1200	1,101	1,057	1,062	1,052	1,046	959	953	948	986	1,215	1,593	1,517	1,552	1,688	1,579
Nitrate as N	10	20	40	>40	5.8	5.6	5.8	5.4	5.6	12	6	11	8.8	8.1	7.8	11	6.3	4.6	4
Nitrite as N	-	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride as F	1.5	2	3	>3	1	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.9	1.4	1.4	1.4	1.3	1.3
Iron as Fe	0.1	1	2	>2	0.01	0.02	0.03	0.03	0.02	0.05	0.02	0.01	0.02	0.03	0.04	0.04	0.05	0.04	<0.02
Manganese as Mn	0.05	1	2	>2	<0.01	<0.01	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Ammonia as N	1	2	4	>4	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Hardness as $CaCO_3$	300	650	1300	>1300	2,344	2,377	2,372	2,367	2,361	2,178	2,274	2,248	2,265	2,307	2,781	2,731	2,813	2,868	2,788
Ca-Hardness as $CaCO_3$	375	500	1000	>1000	1,146	1,166	1,161	1,156	1,146	1,099	1,154	1,136	1,141	1,154	1,229	1,211	1,224	1,291	1,231
Mg-Hardness as $CaCO_3$	290	420	840	>840	1,198	1,211	1,211	1,211	1,215	1,079	1,120	1,112	1,124	1,153	1,552	1,520	1,590	1,577	1,557
Overall Quality Group[10]	-	-	-	-	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**

[8] All constituents are in mg/l unless otherwise stated.
[9] Calculated value
[10] The overall quality group into which a water is classified, is determined by the determinant that complies the least with the guidelines for the quality of drinking water.

Table 3-3: Groundwater Quality of Water Supply Boreholes Compared to the Guidelines for Safe Drinking Water

Constituents[11]	Guidelines For Human Consumption				BH8	BH8	BH8	BH8	BH8	BH9	BH9	BH9	BH9	BH9	BH11	BH11	BH11	BH11	BH11
	Group A	Group B	Group C	Group D	22/01/2022 22:00	23/01/2022 09:40	23/01/2022 21:00	24/01/2022 09:00	24/01/2022 21:00	07/01/2022 20:00	07/01/2022 08:00	08/01/2022 20:00	09/01/2022 08:00	09/01/2022 21:00	16/01/2022 15:00	17/01/2022 02:40	17/01/2022 14:20	18/01/2022 03:40	18/01/2022 15:00
pH	6-9	5.5-9.5	4-11	<4->11	7.3	7	6.9	7	7	7.3	7.3	7.7	7.2	7.2	6.9	6.9	6.9	6.9	7
Electrical Conductivity mS/m	150	300	400	>400	1,107	921	885	884	898	433	428	437	453	474	2,190	2,010	1,961	1,938	1,910
Total Dissolved Solids[12]	-	-	-	-	6,924	5,790	5,537	5,143	5,193	2,490	2,556	2,583	2,605	2,864	14,809	13,410	12,764	12,799	12,371
Turbidity	1	5	10	>10	5.8	0.15	0.2	0.2	0.2	0.7	0.25	0.25	0.3	0.35	0.35	0.3	0.25	0.2	0.2
Calcium as Ca	150	200	400	>400	613	484	469	478	479	156	162	146	178	189	1,126	1,120	1,120	1,087	1,113
Magnesium as Mg	70	100	200	>200	276	220	214	212	218	90	90	93	100	106	554	535	543	535	536
Sodium as Na	100	400	800	>800	1,439	1163	1139	1,127	1,162	677	650	665	662	689	3,448	2,891	2,787	2,723	2,639
Potassium as K	200	400	800	>800	56	50	48	48	49	29	28	29	30	31	110	95	94	91	90
Total Alkalinity as $CaCO_3$	-	-	-	-	200	195	185	185	190	395	395	365	395	385	230	235	235	240	235
Chloride as Cl	250	600	1200	>1200	2,650	2,097	1,982	1,982	1,982	737	830	853	853	876	5,991	5,530	5,185	5,300	4,954
Sulphate as SO_4	200	600	1200	>1200	1,444	1,210	1,133	1,139	1,144	509	504	523	485	678	3,131	2,785	2,656	2,670	2,656
Nitrate as N	10	20	40	>40	73	101	99	10	9.8	12	12	12	13	14	70	70	53	56	54
Nitrite as N	-	-	-	-	0.6	0.86	0.9	1	1.1	0.01	0.01	0.01	0.01	0.02	<0.01	0.01	<0.01	<0.01	<0.01
Fluoride as F	1.5	2	3	>3	1.2	1.3	1.3	1.3	1.3	2	2.1	2	2.1	2	1.3	1.2	1.2	1.2	1.2
Iron as Fe	0.1	1	2	>2	1.8	0.05	0.02	0.02	0.01	0.04	0.01	0.02	0.01	0.02	0.18	0.19	0.49	0.97	0.16
Manganese as Mn	0.05	1	2	>2	<0.02	0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	0.24	<0.1
Ammonia as N	1	2	4	>4	1.1	1.4	2.2	2.1	2.2	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Hardness as $CaCO_3$	300	650	1300	>1300	2,667	2,115	2,052	2,067	2,094	760	775	748	856	908	5,093	5,000	5,033	4,917	4,986
Ca-Hardness as $CaCO_3$	375	500	1000	>1000	1,531	1,209	1,171	1,194	1,196	390	405	365	444	472	2,812	2,797	2,797	2,714	2,779
Mg-Hardness as $CaCO_3$	290	420	840	>840	1,137	906	881	873	898	371	371	383	412	437	2,281	2,203	2,236	2,203	2,207
Overall Quality Group[13]	-	-	-	-	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D

[11] All constituents are in mg/l unless otherwise stated.
[12] Calculated value
[13] The overall quality group into which a water is classified, is determined by the determinant that complies the least with the guidelines for the quality of drinking water.

Table 3-3: Groundwater Quality of Water Supply Boreholes Compared to the Guidelines for Safe Drinking Water

Constituents[14]	Guidelines For Human Consumption				BH12	BH12	BH12	BH12	BH12	K5 Pit
	Group A	Group B	Group C	Group D	11/01/2022 09:00	11/01/2022 21:40	12/01/2022 09:20	12/01/2022 21:00	13/01/2022 09:00	25/01/2022
pH	6-9	5.5-9.5	4-11	<4->11	7.1	7.1	7.2	7.2	7.2	7.5
Electrical Conductivity mS/m	150	300	400	>400	838	812	802	3,260	785	3270
Total Dissolved Solids[15]	-	-	-	-	5,262	5,022	5,075	22,768	4,826	22,763
Turbidity	1	5	10	>10	0.25	0.3	0.3	3	0.6	4.8
Calcium as Ca	150	200	400	>400	473	450	451	986	420	979
Magnesium as Mg	70	100	200	>200	229	216	215	1004	201	1023
Sodium as Na	100	400	800	>800	1,121	1,069	1,081	5,596	1,000	5,505
Potassium as K	200	400	800	>800	52	51	51	232	50	236
Total Alkalinity as $CaCO_3$	-	-	-	-	385	285	345	190	345	133
Chloride as Cl	250	600	1200	>1200	1,843	1,751	1,751	9,332	1,728	9,102
Sulphate as SO_4	200	600	1200	>1200	1,035	1,052	1,062	5,449	1,002	5,830
Nitrate as N	10	20	40	>40	62	59	58	12	49	1.4
Nitrite as N	-	-	-	-	0.07	0.04	0.05	0.13	0.06	0.22
Fluoride as F	1.5	2	3	>3	1.4	1.4	1.4	2.1	1.4	1.9
Iron as Fe	0.1	1	2	>2	0.02	0.03	0.02	<0.1	0.02	0.18
Manganese as Mn	0.05	1	2	>2	<0.01	<0.01	<0.01	<0.1	<0.01	0.21
Ammonia as N	1	2	4	>4	<0.02	<0.02	0.49	0.44	<0.02	1.2
Total Hardness as $CaCO_3$	300	650	1300	>1300	2,124	2,013	2,012	6,597	1,876	6,657
Ca-Hardness as $CaCO_3$	375	500	1000	>1000	1,181	1,124	1,126	2,462	1,049	2,445
Mg-Hardness as $CaCO_3$	290	420	840	>840	943	889	885	4,134	828	4,213
Overall Quality Group[16]	-	-	-	-	**D**	**D**	**D**	**D**	**D**	**D**

[14] All constituents are in mg/l unless otherwise stated.
[15] Calculated value
[16] The overall quality group into which a water is classified, is determined by the determinant that complies the least with the guidelines for the quality of drinking water.

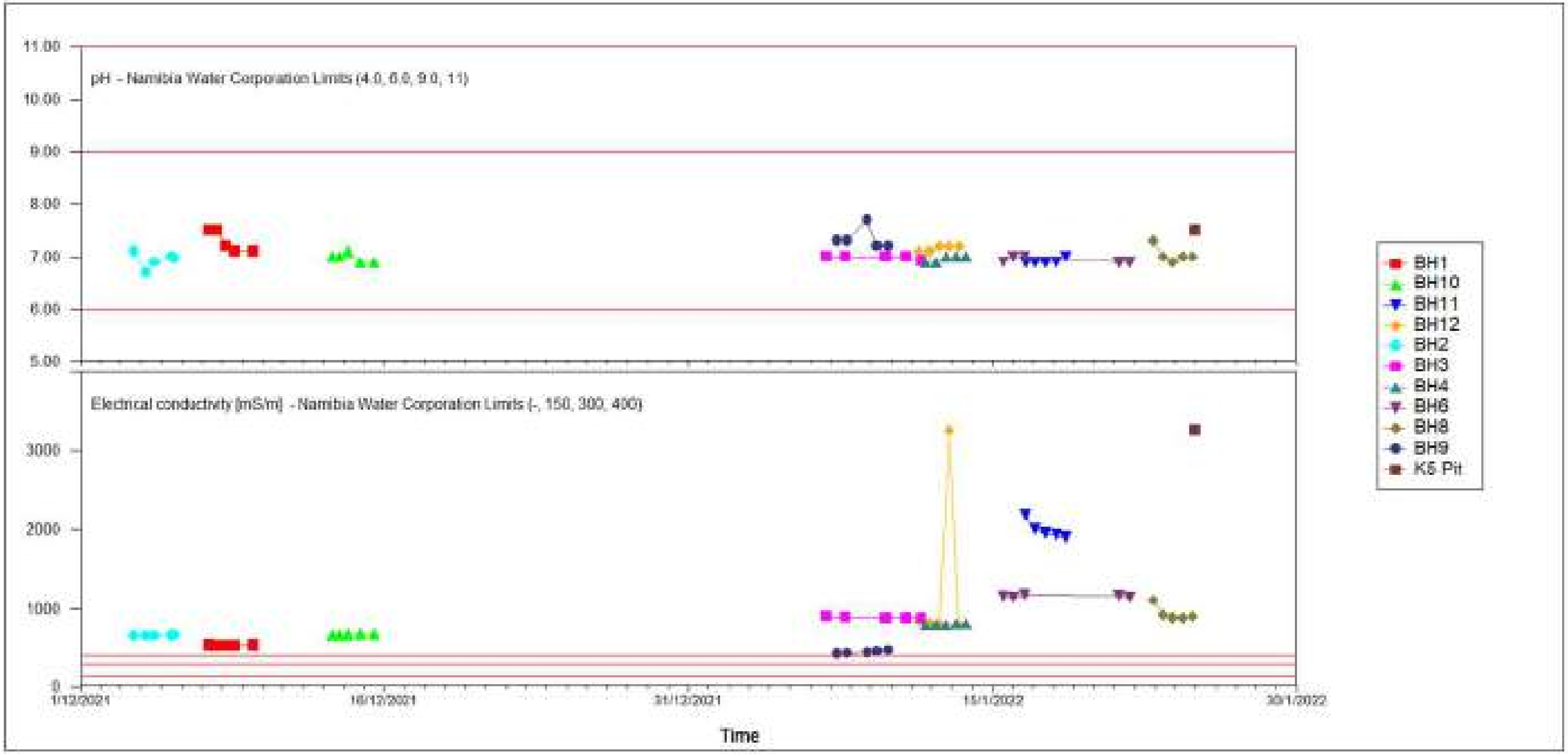

Figure 3-14: Electrical Conductivity Trends

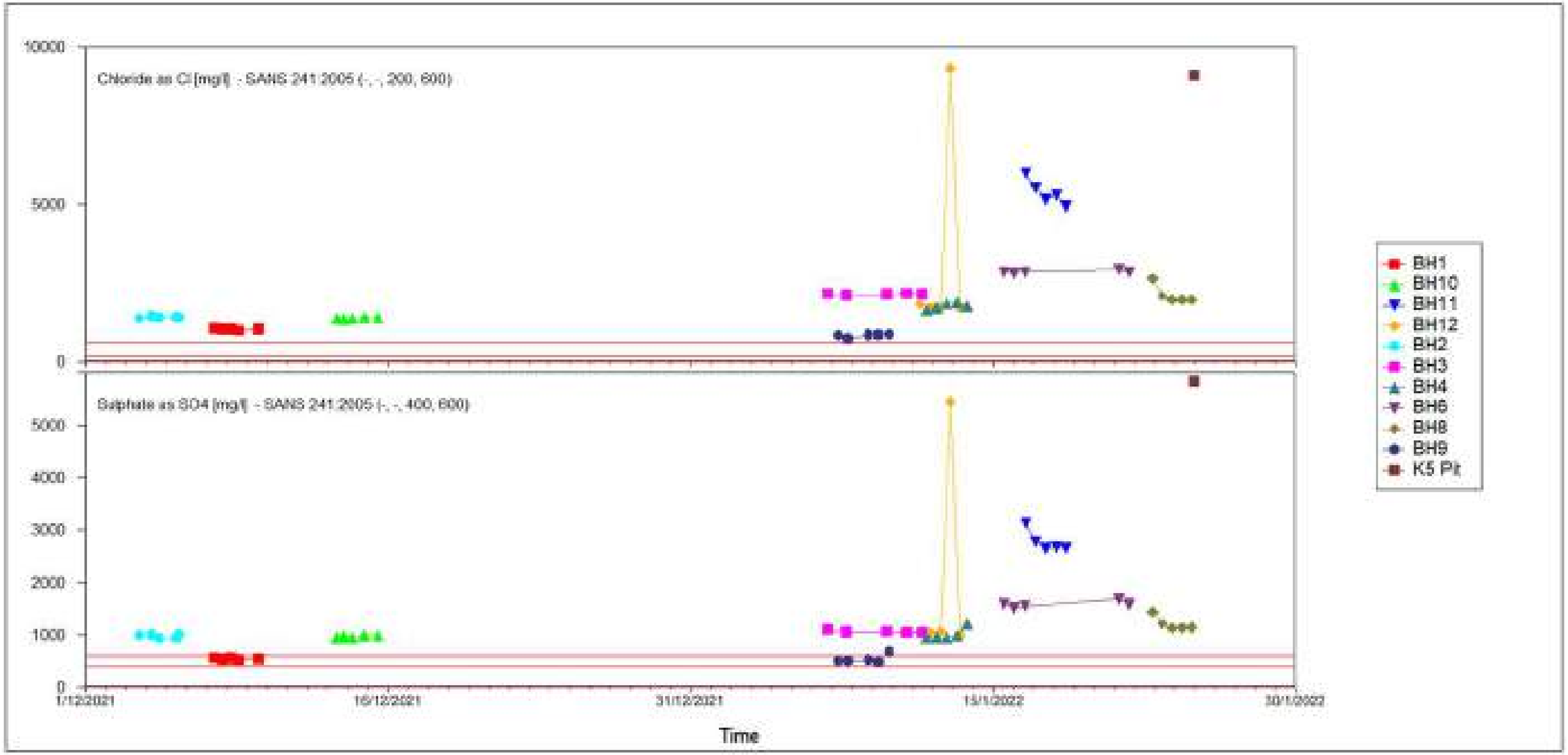

Figure 3-15: Chloride and Sulphate Trends

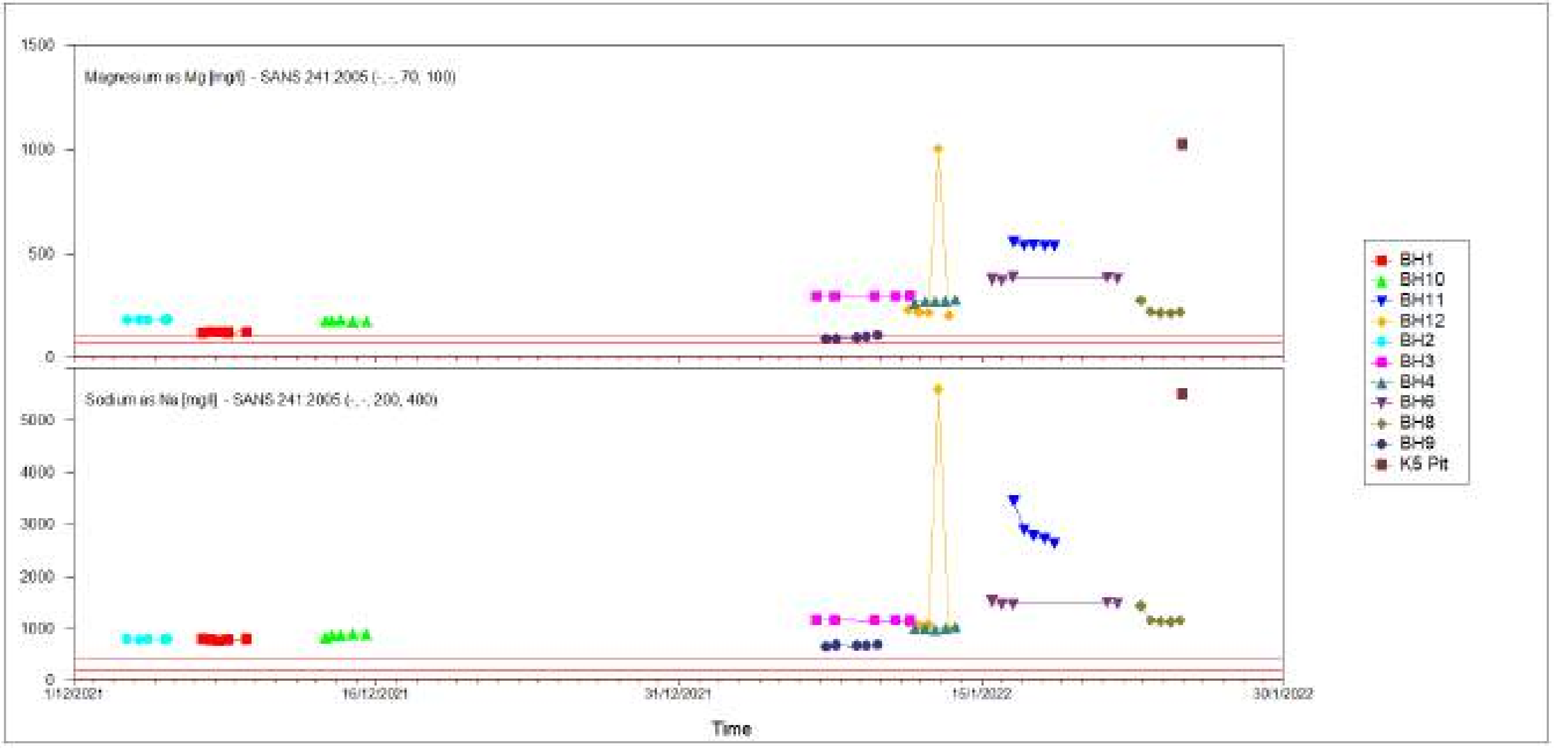

Figure 3-16: Magnesium and Sodium Trends

Table 3-4: Corrosion/Scaling Indices

	BH1	BH2	BH10	BH3	BH4	BH6	BH8	BH9	BH11	BH12	K5 Pit
Langelier Index	0.78	0.58	0.62	0.68	0.66	0.64	0.46	0.60	0.72	0.76	1.00
	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency
Ryznar Index	5.70	5.74	5.78	5.62	5.72	5.64	6.16	6.14	5.48	5.60	5.50
	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency	Scale-forming tendency
Corrosivity Ratio	3.72	7.52	7.08	10.32	9.26	14.02	22.36	4.48	44.76	28.36	142.3
	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion	Tendency towards progressive corrosion

3.4.3. Aquifer Testing

Hammerstein Mining and Drilling tested the water supply boreholes between 5 December 2021 and 25 January 2022. The duration of the aquifer tests was planned for 48 hours for each borehole. A summary of these aquifer tests is provided in Table 3-5. The methodology is provided in Appendix A and the test data, observation comments and Aqtesolv interpretations are provided in Appendix C.

The aquifer test data was interpreted using the FC method and Aqtesolv (Version 4.5 professional). The FC method was used to determine the sustainable yield (Table 3-8) for the boreholes whilst Aqtesolv was used to interpret the hydraulic parameters for the aquifer (Table 3-6). The solutions used in the Aqtesolv software include the Cooper-Jacob, Theis and Theis Recovery for confined aquifers as well as the Moench solution for fractured aquifers.

Although the applied methodology for calculating hydraulic parameters is based on assumptions which may differ from actual site conditions (e.g., infinite areal extent, homogenous and isotropic aquifer conditions, no delayed gravity response of aquifer), the resulting hydraulic parameter from these calculations are representative of the aquifer system in the vicinity of the tested boreholes.

The hydraulic conductivities calculated from the Moench solution indicate a range between 0.1 – 3.5 m/d with an average of 0.8 m/d, a harmonic (harmean) mean of 0.2 m/d and a geometric (geomean) mean of 0.3 m/d. The transmissivities calculated from the Cooper-Jacob and Theis solutions indicate a range between 0.6 – 586 m^2/d with an average of 51 m^2/d, a harmean of 6 m^2/d and a geomean of 18 m^2/d. The previous aquifer test data was interpreted with Aqtesolv, and a similar range of hydraulic conductivities and transmissivities were obtained (Table 3-7).

The hydraulic conductivities calculated from the water supply boreholes correspond to what is expected for fractured igneous and metamorphic rocks which can range between $1x10^{-3}$ – $1x10^{1}$ m/d (Domenico & Schwartz, 1990). The results also correspond with the hydraulic conductivities for a study undertaken for the Swakop River Catchment (within the Damara Orogen) which indicates that the hydraulic conductivities can range between $8.6x10^{-4}$ – 0.86 m/d in fractured aquifers with a moderate groundwater potential and between $8.6x10^{-4}$ – 8.6 m/d in fractured aquifers with a high groundwater potential (Winker, 2010).

The combined average sustainable yield for all the aquifer tested boreholes is 18.7 m^3/hr (Table 3-8)[17].

During the aquifer test on BH9 it was observed that the installed pump had iron oxide deposits and that roots were growing within the borehole. An initial recommendation would be to clean borehole BH9 to assess if yields can be improved.

- Roots could be removed by welding steel blades onto a heavy rod. Sharper blades should be positioned on the lower portion to assist with cutting roots when the rod is

[17] The average sustainable yield provides an intermediate estimation between the 1 and 2 no flow boundaries which is likely to be present on site. A no flow boundary is an impermeable unit that does not allow flow through it (i.e., dyke, sealed fault)

being lowered and blunter blades can be positioned higher up to assist with grabbing the loose roots when pulling the rod out of the borehole. An auger-type fitting may also be an option. The borehole will need to be cleaned regularly to prevent the roots regrowing;

- Complete a downhole camera survey to assess if the fractures are blocked which may need to be flushed, brushed or redrilled to a slightly larger diameter to try clear surface deposits on the borehole walls which may be blocking yields;
- Chemical additives could be used provided this doesn't interfere with the water chemistry needed in the plant or surrounding water supply boreholes; and
- Alternative boreholes may need to be drilled or located to supplement water supply during borehole maintenance periods.

It is also recommended to clean BH2. The 2021 aquifer test on BH2 was done at a reduced rate of 2m^3/hr (compared to the previous 6 m^3/hr) and resulted in a higher drawdown compared to the original test (15 m compared to the previous 5 m). This may indicate that scaling could be affecting the operation of the borehole.

Table 3-5: Aquifer Test Summary

Borehole	Test	Test Duration (hours)	Test Rate (m^3/hr)	Test Rate (l/s)	Pump Depth (mbgl)	Borehole Depth (m)	SWL (mbgl)	Drawdown (m)	Observation Boreholes	Lithology	Main Water Strike Depth (m)	Comment
BH1	CDT 1	16	8	2.2	44	48	24.20	18.79	BH2, BH10	Quartzite	27	Yield was not sustainable. Casing has been installed.
	CDT 2	24	5	1.4	44	48	25.13	2.48		Quartzite	27	Casing has been installed.
BH2	CDT 1	48	2	0.6	50	54	29.95	15.16	BH1, BH10	Quartzite	31	No casing installed.
BH3	CDT 1	5	3	0.8	56	60	17.10	35.21	BH4, BH6	Quartzite, Schist	27	Yield was not sustainable. No casing installed.
	CDT 2	52	2	0.6	56	60	16.80	8.12		Quartzite, Schist	27	Rate was initially set to 4 m^3/hr (pressure issues in the pipes). No casing installed
BH4	CDT1	48	4.5	1.3	86	90	21.89	12.62	BH3, BH6	Pegmatite, Quartz, Schist	48	No casing installed.
BH5	Collapsed at 15.45 mbgl											
BH6	CDT 1	11	15	4.2	70	90	17.41	49.83	BH3, BH4	Unknown	Unknown	Accidentally started at 18 m^3/hr reduced to 15 m^3/hr. Yield was not sustainable
	CDT 2	8	11	3.1	70	90	20.65	26.02		Unknown	Unknown	Yield was not sustainable
	CDT 5	28	6	1.7	70	90	19.32	8.18		Unknown	Unknown	
BH8	CDT1	48	18.5	5.1	70	118	37.00	5.14	BH11	Schist, Pegmatite	50, 85, 106, 111	Casing has been installed.
BH9	CDT1	48	7.5	2.1	96	100	34.46	38.78	BH10, BH12	Schist, Quartz	46, 70	No casing installed.
BH10	CDT 1	8	12	3.3	54	58	33.56	1.48	BH1, BH2	Quartzite	28, 32, 40	Pumped at a lower rate to verify yield and fill plant reservoir. Casing has been installed.
	CDT 2	40	18	5.0	54	58	34.14	3.32		Quartzite	28, 32, 40	Casing has been installed.
BH11	CDT1	48	9.6	2.7	74	78	41.25	14.60	BH8	Unknown	Unknown	
BH12	CDT1	48	2.5	0.7	54	58	31.90	7.60	BH9	Unknown	Unknown	Rate was increased to 3 m3/hr after 24 hours

Table 3-6: Summary of Hydraulic Parameters

		Literature	Swakop River Catchment Study	Fractured Aquifer		Cooper Jacob (Early)	Cooper Jacob (Late)	Theis Recovery (Early)	Theis Recovery (Late)	Theis (Early)	Theis (Late)	Theis (Recovery)
		k (m/d)	k (m/d)	k (m/d)	Ss (m-1)	T (m^2/d)						
BH1	2021 CDT1			1.8	$2.3x10^{-2}$	36.8	0.8	2.1	30.4	39.7		28.1
	2021 CDT2			1.9	$1.1x10^{-2}$	42	28.4	43.7	21.2	31.9		29.8
BH2	2021 CDT1			0.2	$5.7x10^{-2}$	9.1	3.3	0.5	14.7	-	-	4.9
BH3	2022 CDT1			0.1	$1.9x10^{-4}$	0.6	3.4	2.6	1.4	3.3		-
	2022 CDT2			0.1	$1.1x10^{-4}$	4.9	1.8	4.2	2	-	-	3.9
BH4	2022 CDT1			0.2	$2.8x10^{-5}$	5.2	13.4	1.8	63.3	-	-	11.1
BH6	2022 CDT1			0.1	$7.4x10^{-20}$	38	37.5	32.8	-	36.87	37.9	-
	2022 CDT2			0.1	$1.5x10^{-5}$	82.1	6.4	54.8	14	85.1	9	7.9
	2022 CDT3			0.1	$1.4x10^{-3}$	84.5	3.8	92.6	8.1	99	4.2	3.7
BH8	2022 CDT1			0.5	$3.4x10^{-4}$	257.8	25.4	586	176.5	257.8	25.9	27.2
BH9	2022 CDT1			0.1	$1.8x10^{-6}$	8.5	1	1.2	9.4	3.7		4.4
BH10	2021 CDT1			3.5	0.1	154	84.3	215.5	195.9	183.4	73.3	81.6
	2021 CDT2			3.2	0.2	182.2	39.1	162.2	80.8	163	35.9	57.7
BH11	2022 CDT1			0.2	$5.1x10^{-2}$	32.8	4.3	16.6	7.7	34.1	4.5	-
BH12	2022 CDT1			0.4	$2.1x10^{-4}$	20.7	2.3	3.8	12.6	-		12.29
Minimum		**0.001**	**$8.6x10^{-4}$**	**0.1**	**$7.4x10^{-20}$**	**0.6**						
Maximum		**10**	**8.6**	**3.5**	**0.2**	**586**						
Average		**-**	**-**	**0.8**	**0.03**	**50.8**						
Harmonic Mean		**-**	**-**	**0.2**	**$1.1x10^{-18}$**	**5.9**						
Geometric Mean		**-**	**-**	**0.3**	**$1.0x10^{-4}$**	**17.6**						

Table 3-7: Summary of Previous Aquifer Test Parameters

	2018 Test Rate (m^3/hr)	2018 SWL (mbgl)	2018 Drawdown (m)	Fractured Aquifer		Cooper Jacob (Early)	Cooper Jacob (Late)	Theis Recovery (Early)	Theis Recovery (Late)	Theis (Early)	Theis (Late)	Theis (Recovery)
				k (m/d)	**Ss (m-1)**	**T (m^2/d)**						
BH1	5	21.05	1.69	1.7	5.3x10^{-5}	90.5	47	72.2	43.6	-	-	51.7
BH2	6	23.24	5.06	0.9	6.6x10^{-6}	34.4	22.7	42.1	23.5	-	-	27.1
BH3	2	14.75	4.6	0.1	3.4x10^{-4}	6.7	-	8.2	-	-	-	7.4
BH4	3	15.11	8.14	0.1	9.9x10^{-7}	3	55.6	2	90.5	-	-	55.6
BH5	2.5	14.92	31.75	0.05	1.8x10^{-2}	4.8	2.3	-	1.8	2		-
BH6	6	16.6	1.83	0.2	1.4x10^{-4}	94.1	25.5	107.1	43.5	109.8	19.7	-
BH8	17.5	36.93	2.16	1.2	8.2x10^{-7}	855.2	79.3	957.9	122.5	747.2	73.4	-
BH9	6	30.07	7.86	0.3	2.8x10^{-7}	13.2	18.4	33.4	36.4	-	-	21.2
BH10	19	23.03	19.7	2.3	0.2	298.2	112.1	239.8	114.3	-	-	109.6
Minimum				**0.05**	2.8x10^{-7}	**2**						
Maximum				**2.3**	**0.2**	**958**						
Average				**0.8**	**0.02**	**112**						
Harmonic Mean				**0.2**	**1.5x10^{-6}**	**12**						
Geometric Mean				**0.4**	**6.2x10^{-5}**	**38**						

Table 3-8: Sustainable Yield Interpretations

Borehole	Sustainable Yield (m³/hr)				
	No Boundaries[18]	1 No Flow Boundary	2 No Flow Boundaries	4 No Flow Boundaries	Average
BH1	0.9	0.5	0.4	0.2	0.4
BH2	0.4	0.3	0.2	0.1	0.2
BH3	0.6	0.4	0.3	0.1	0.3
BH4	2.1	1.3	0.9	0.5	1.0
BH6	2.2	1.2	0.8	0.4	1.0
BH8	16.6	10.2	7.4	4.1	8.5
BH9	1.9	1.1	0.8	0.4	0.9
BH10	7.6	4.9	3.6	2.0	4.0
BH11	3.0	1.7	1.2	0.6	1.4
BH12	1.9	1.2	0.9	0.5	1.0
Total Yield	**37.2**	**22.7**	**16.4**	**9.0**	**18.7**

[18] A no flow boundary is an impermeable unit that does not allow flow through it (i.e., dyke, sealed fault).

4. Conceptual Model

The conceptual model describes the hydrogeological environment and is used as input into the numerical model to represent simplified, but relevant conditions of the groundwater system. The conceptual model is based on the source-pathway-receptor principle.

4.1. Sources

4.1.1. Recharge

The NA-MIS (Namibian Monitoring Information System) and hydrogeological map of Namibia indicates the project area has an effective groundwater recharge percentage of 0% of the average annual recharge. Surrounding areas associated with the mica schists of the Kuiseb Formation and the marbles of the Karibib Formation can receive up to a maximum of 0.5% of the average annual recharge (Groundwater Management Institute, 2022). With an average annual rainfall of 88 mm, the recharge to isolated areas of the project area could be a maximum of 0.44 mm/a.

A rainwater sample was collected on 19 January 2022 and submitted to a SANAS accredited laboratory for chloride analysis. Chloride can be used as a tracer to estimate the recharge to the groundwater aquifers using the following equation:

$$R = P.\frac{Clp}{Clgw}$$

Where R is the groundwater recharge flux, P is the average annual precipitation, Cl_p is the average chloride concentration for precipitation and Cl_{gw} is the average chloride concentration for groundwater.

The results of the chloride method estimate indicate approximately 0.7% (0.61 mm/a) of rainfall contributes to recharging the groundwater aquifer in the project area. This would indicate a maximum contribution percentage as the equation above does not account for surface water runoff or the presence of chloride in the environment (i.e., gypsum) which may influence the chloride concentration recharging to or occurring within the aquifer.

4.2. Pathways

4.2.1. Aquifers

The project area comprises of igneous (local pegmatites and regional granites) and metamorphic (schist and quartzite) rocks with alluvial sediment cover in the Uis river channel. Two aquifers have been interpreted based on the available information.

4.2.1.1. Alluvial Aquifer

An alluvial aquifer occurs predominantly within river channels but can also be present as a surface cover overlaying the fractured aquifer (Figure 3-4).

Observations on site indicate that the alluvial sediments are coarse-grained. Coarse-grained unconsolidated sediments can have a range in hydraulic conductivity of between 0.08 – 518 m/d (Domenico & Schwartz, 1990). The drill logs of the water supply boreholes indicate that the alluvial sediments in the Uis and Southern wellfield river channels vary between 2 – 13 m thick, with an average thickness of 5.5 m. The static water levels measured in the water supply boreholes occur below the alluvial aquifer indicating this aquifer will be important for recharging the underlying fractured aquifer but is of low importance for water supply.

4.2.1.2. Fractured Aquifer

Majority of the project area is exposed as schists (meta-pelites), marble or granites (Figure 3-4). Intrusive and metamorphic rocks typically have poor aquifer properties but can yield successful boreholes if secondary fracture or fault features are intersected. Marble aquifers can have a higher groundwater potential if karstic features have developed, however yields may still be dependent on the degree of weathering and availability of rainfall for recharge.

The NA-MIS (Namibian Monitoring Information System) and hydrogeological map of Namibia indicates that the geology of the project area has a very low and limited groundwater potential. The schists (Kuiseb Formation) and the marbles (Karibib Formation) are considered to have a low potential for groundwater, but localised areas can have a higher moderate potential for groundwater. The NA-MIS hydrogeological map indicates that the project area occurs in the region with the lowest abstraction volume (Groundwater Management Institute, 2022).

The hydraulic conductivity of igneous and metamorphic rocks can range between $1x10^{-3}$ – $1x10^{1}$ m/d for fractured rocks and between $3x10^{-9}$ – $2x10^{-5}$ m/d in unfractured rocks (Domenico & Schwartz, 1990). The aquifer testing results indicates that the fractured aquifer in the project area occurs within the expected range of hydraulic conductivities (ranging between 0.01 – 7 m/d with an average of 0.9 m/d).

The weathering profiles for the water supply boreholes indicate that the fractured aquifer is weathered to an average depth of 25 m and has a higher frequency of fractures between 20 – 50 m. Although the fracture frequency decreases after 50 m the fractures that are intersected can still be high yielding. Initial groundwater levels measured in 2018 indicate that the water table typically occurs within the weathered zone of the fractured aquifer. Abstraction from the Uis wellfield boreholes since operations began in 2020 has drawn down the water levels in these boreholes by between 2.4 – 7.8 m. Groundwater levels within the Southern wellfield have decreased by an average of 1.4 m between 2018 and 2022, even though these boreholes are not operational.

4.3. Receptors

AfriTin have two wellfields from which water can be drawn to supply the processing plant. The Uis wellfield is located in the Uis river, which runs through the mine area. There are seven boreholes located in this wellfield which are currently being used to supply water to the plant. The Uis wellfield boreholes are located within 2 km of each other and are expected to provide a combined average sustainable yield of 16.4 m^3/hr. Two third-party boreholes are located in Uis River catchment.

The Southern wellfield is located within a river channel approximately 6 km south of the mine and comprises of three boreholes. A fourth low yielding borehole was drilled in this wellfield but has subsequently collapsed. The Southern wellfield is not currently operational. The three boreholes in the southern wellfield are located within 700 m of each other and are expected to provide a combined average sustainable yield of 2.3 m^3/hr.

5. Numerical Model

A finite difference numerical groundwater flow model was constructed based on the conceptual model for the Uis Tin Mine. The numerical model was calibrated and verified with the available monitoring data.

The numerical model was constructed using GMS 10.5.9, a pre- and post- processing package for MODFLOW and MT3DMS. MODFLOW is a three-dimensional groundwater flow model published by the United States Geological Survey (USGS). MODFLOW is a widely used simulation code which is well documented.

The numerical model was constructed to represent the hydrogeological units as described in Section 4 for the alluvial, weathered, highly fractured and low fractured aquifers. The model thickness was set at 250 m to accommodate the maximum depth of abstraction boreholes (maximum of 90 mbgl) but also to allow incorporation of the topography and extents and depths of geological units.

5.1. Model Confidence Level Classification

The level of confidence depends upon the available data for the conceptualisation, design and construction of the model. Consideration was given to the spatial and temporal coverage of the available datasets to characterise the aquifer and the historic groundwater behaviour that was useful for model calibration.

Factors that affect the model confidence level include the type and quality of data used for model calibration, the degree to which the model was able to reproduce observations, and whether the model was able to represent present-day hydrogeological conditions during the calibration procedure. For the calibration process, the following data was available for the project:

- Surface geology maps for the mining and wellfield areas;
- Geological logs and aquifer tests for 11 boreholes, in the alluvial aquifer and weathered and highly fractured parts of the underlying lithologies, mainly in meta-sedimentary rocks and pegmatite;
- Historic groundwater level data for 21 boreholes, mostly in the Uis Riverbed and at the southern wellfield, with most boreholes intersecting thin alluvial deposits on top of fractured rock; and

- Recharge estimations based on available information for the region.

Based on a semi-quantitative assessment of the available data on which the model was based on and the manner in which the model was calibrated, the model was classified as a Class 1 model using the Australian Guidelines (Australian Government - National Water Commission, 2012).

This model could be updated to a Class 2 model should the following data become available:

- Obtain additional hydraulic parameters such as transmissivity and hydraulic conductivity of rock units present in the area surrounding the mine site, including to the north, east and south of the mine site;
- Periodical, long-term groundwater water level monitoring in the surrounding area of the mine;
- Increased accuracy of recharge estimates; and
- Flow measurements in the Uis River.

5.2. Model Setup

The conceptual model was translated into the numerical model during the model setup. This involves:

- Defining the model domain and boundary conditions;
- Discretising the data spatially and over time;
- Defining the initial conditions;
- Selecting the aquifer types; and
- Preparing the model input data.

5.2.1.1. Model Domain

The model domain is irregularly shaped with approximate dimensions of 33 km west-east by 25 km north-south, which is a relatively large model area due to the size of the catchment. The model grid was discretised by 974 x 708 cells in the x and y direction for 8 model layers, resulting in a total of 5 146 616 active cells. A grid refinement of 10 m x 10 m cells covering the area including the wellfields was applied with gradually coarser grid cell sizes to a maximum size of 300 m x 300 m away from the abstraction boreholes to reduce model run time (Figure 5-1).

5.2.1.2. Time Discretisation

Time parameters are relevant when modelling transient (time-dependent) conditions. They include time units, the length and number of stress periods and the number of time steps within each stress period. All model parameters associated with boundary conditions and various stresses remain constant during one stress period.

For the purpose of simulation of borehole abstraction, transient simulations was discretized into stress periods as follows:

- For the production borehole abstraction: monthly stress periods with average abstractions and drawdowns.

Stress periods were subdivided in timesteps to allow for accurate iterations as follows:

- Yearly stress periods divided in 10-time steps; and
- Monthly stress periods divided in 10-time steps.

5.2.1.3. Boundary Conditions

Boundary conditions are sets of differential equations that must be solved to express the known water fluxes and variables (such as hydraulic heads) within the model domain. Local hydraulic boundaries were identified for the model boundary, which are represented by local water courses and topographical highs. These hydraulic boundaries as shown in Figure 5-1 and detailed in Table 5-1 were selected far enough from the proposed mining activities so that the boundaries don’t influence the numerical model artificially.

Table 5-1: Identification of Real-World Boundaries and Adopted Model Boundary Conditions

Boundary	Boundary Description	Boundary Condition
Top	Top surface of water table	Mixed type: Drain cells for non-perennial streams. Different recharge rates were assigned for different recharge areas (based on topography and available information) and hydrogeological units. Recharge flux was applied to the highest active cell.
North	Topographical / non-perennial stream	Drain and constant head boundaries
East	Geological contact / topographical	Constant head boundary
South	Topographical / non-perennial stream	Drain and constant head boundaries
West	Non-perennial streams	Drain boundary

As input into the numerical model, the following assumptions were made for the Uis Tin Mine:

- Available groundwater levels for historical and current boreholes were used for steady state calibration;
- For transient calibration, the following was used:
  - Drawdown and abstraction data for the current production boreholes (period September 2020 – March 2022).

The most up-to-date abstraction data, as received from Uis Tin Mine, was used as input for the numerical model. The extent and depth of hydrostratigraphic units were determined based on a combination of the available regional and local surface geology and borehole lithological logs and is shown in Figure 5-2 to Figure 5-3.

5.2.1.4. Input Parameters

Model input parameters for this groundwater flow model are divided into two groups:

- hydrogeological parameters; and
- initial conditions.

Initial estimates for hydraulic properties were assigned based on pump test results as carried out as part of the fieldwork. Initial head conditions were estimated based on measured groundwater levels. Recharge rates were applied to different hydrogeological units and recharge areas within the model area as a percentage of MAP. These rates were based on topography (there is an elevated area along the eastern boundary of the model for which available data indicated a recharge rate of >0.5% of MAP) and recharge rates for the different lithological units for the remainder of the model. The highest recharge was used as input for the elevated area (high recharge area), followed by the sediments, due to them receiving higher infiltration rates when compared to areas underlain by weathered rocks. For the steady-state and transient models an annual recharge rate was used (Table 5-2).

Table 5-2: Annual Recharge Values for Hydrogeological Units

Hydrogeological unit	Percentage of MAP	Recharge rate (m/d)
Sediments	0.4%	1.1×10^{-6}
Meta-sedimentary rocks	0.1%	2.7×10^{-7}
Granite	0.08%	2.1×10^{-7}
Schist	0.08%	2.1×10^{-7}
Higher recharge area	1%	2.7×10^{-6}

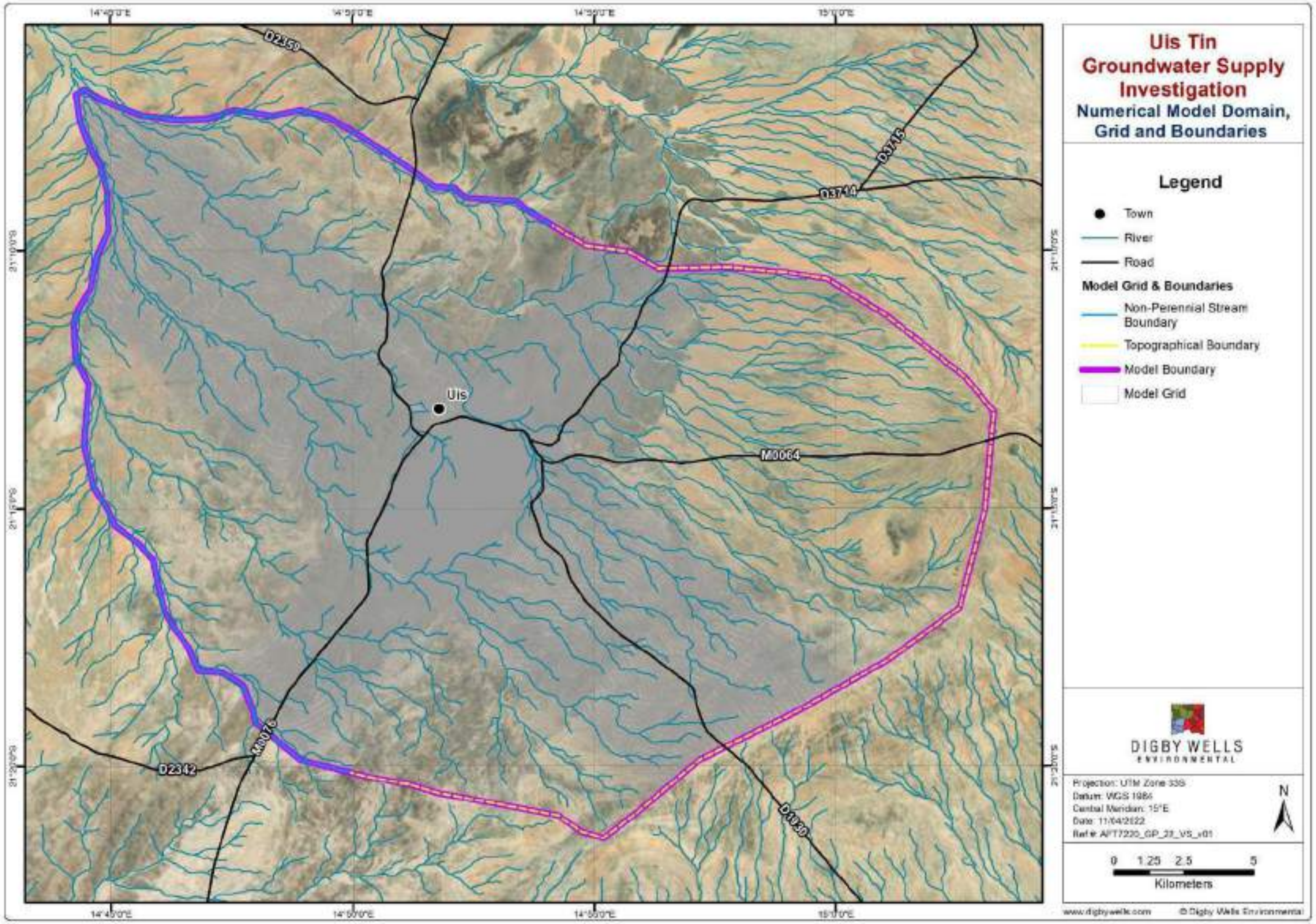

Figure 5-1: Numerical Model Domain, Grid and Boundaries

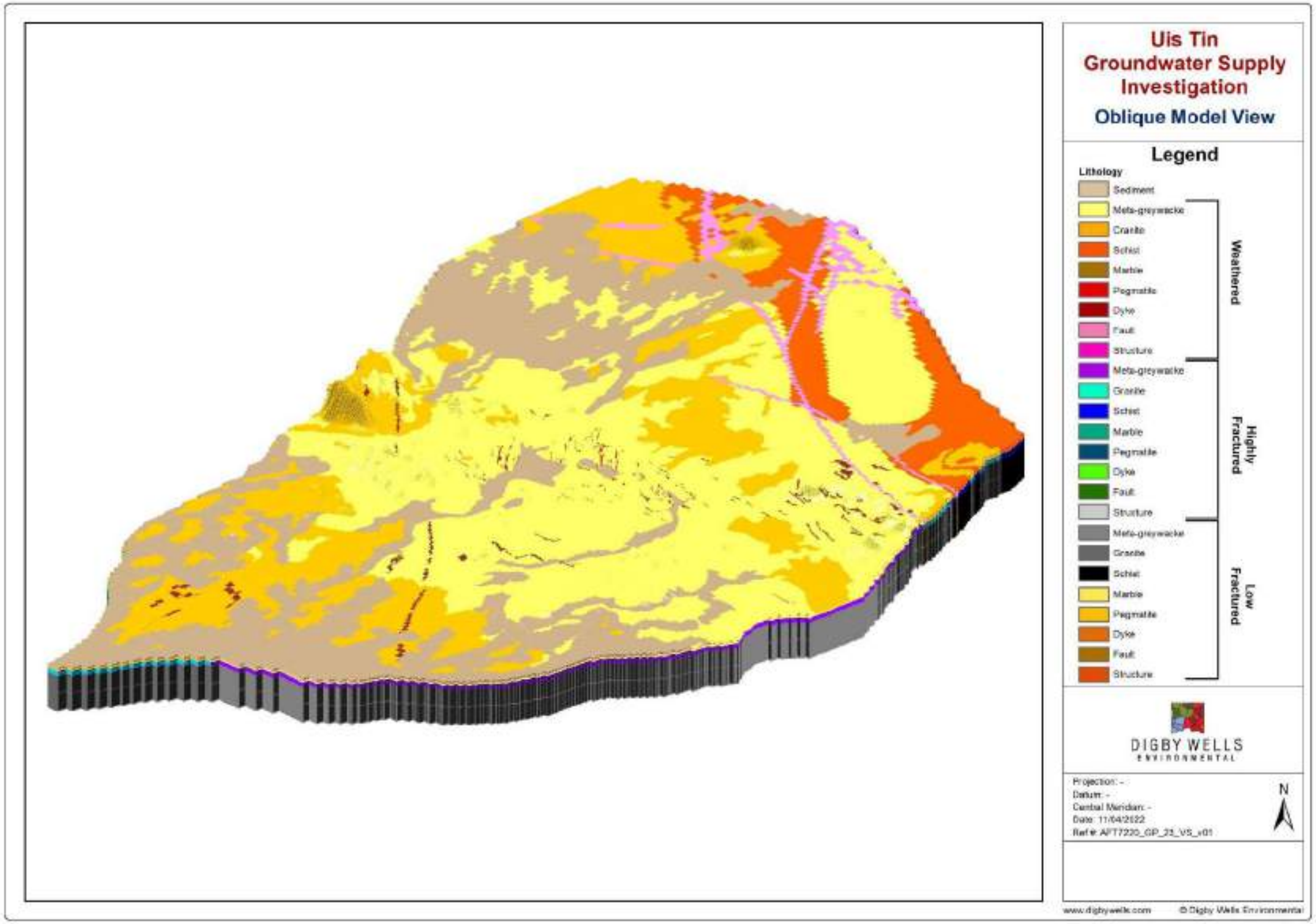

Figure 5-2: Oblique Model View

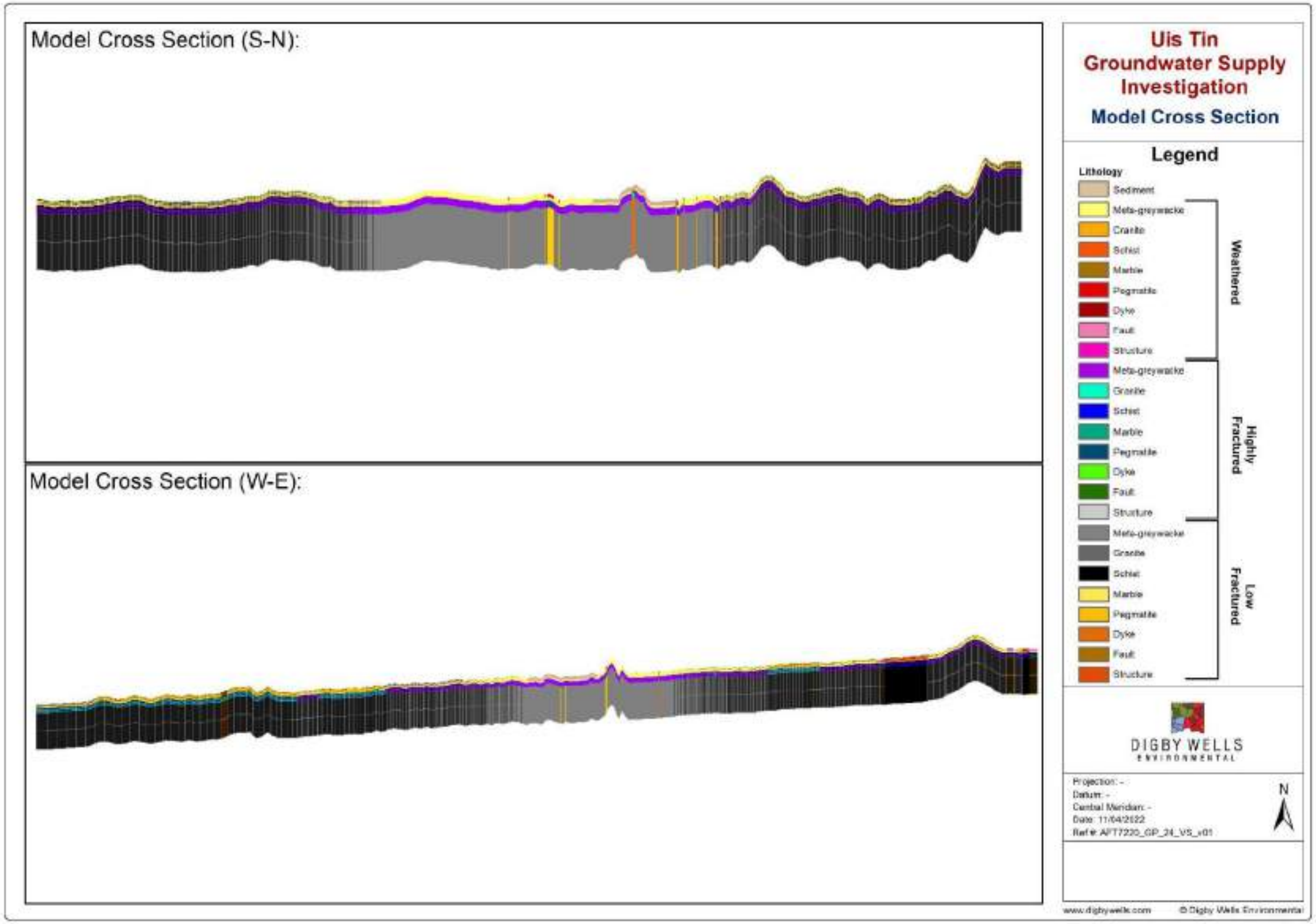

Figure 5-3: Model Cross-Sections

5.2.1.5. Steady State Simulation

Calibration is the process of finding a set of boundary conditions, stresses and hydrogeological parameters that produce results that most closely match field measurements of hydraulic heads and flows. In a regional groundwater flow model, a difference between calculated and measured heads of up to several meters can be tolerated and is usually expressed as a function of the total range of observations.

The calibration was undertaken for steady state conditions as the hydrogeological system is at current not impacted by mining activities. Based on available information, groundwater levels measured in 17 boreholes in total were used for model calibration.

The numerical model calculated head distribution ($h_{x,y,z}$) is dependent upon the recharge, hydraulic conductivity and boundary conditions. For a certain timestep and a given set of boundary conditions, the simulated head distribution across the aquifer can be obtained for a given set of hydraulic conductivity values and specified recharge values. This simulated head distribution can then be compared to the measured head distribution and the hydraulic conductivity and/ or recharge values can be altered until an acceptable correspondence between measured and simulated heads is obtained.

Steady-state calibration of the Uis Tin Mine model area was accomplished by refining the vertical and horizontal hydraulic conductivity until a reasonable resemblance between the measured and simulated piezometric levels was obtained. This was done by a combination of PEST and manual calibration using aquifer zone properties for all model layers.

The steady-state calibration was regarded as sufficient at ME= -2.37 m, MAE =5.51 m and RMSE = 6.5 m. The graph in Figure 5-4 shows the relation between measured and simulated head at the end of steady state calibration process. The calibration results show a 91 % correlation between measured and observed values which is deemed acceptable.

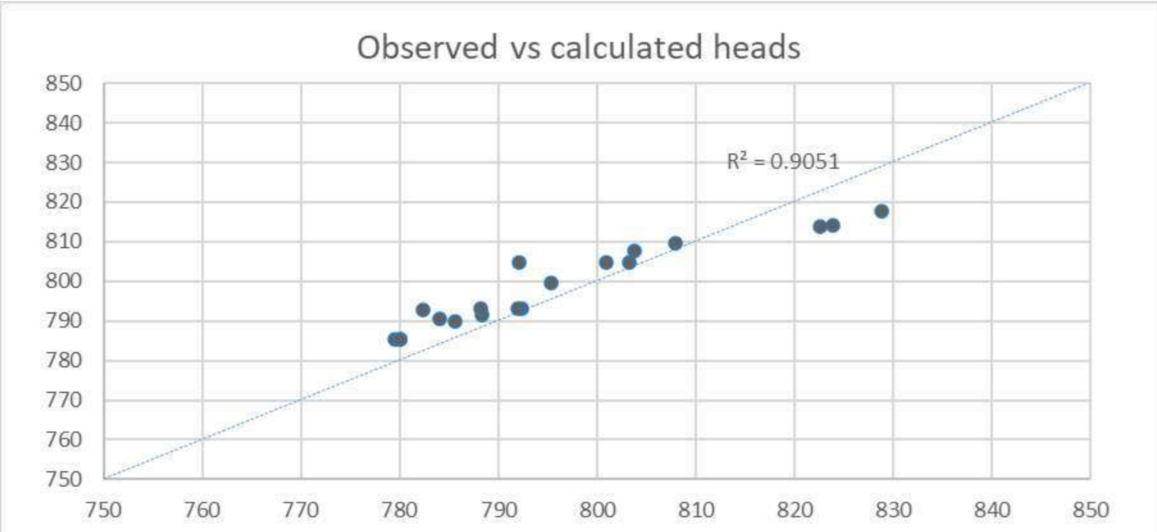

Figure 5-4: Steady State Calibration Results

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 the entire model domain for the steady state stress period achieved a water balance error of 0.03% (Table 5-3).

Table 5-3: Mass Balance: Steady State Model

Description	Flow In (m^3/day)	Flow Out (m^3/day)
Recharge	498.9	-
Drains	-	4476.4
Head dependant bounds	6046.9	2071.1
TOTAL FLOW	6545.8	6547.1
Summary	**In - Out**	**% difference**
Total	-1.65	0.03

5.2.1.6. Aquifer Hydraulic Conductivity

The calibrated hydraulic conductivities used in the steady-state model are listed in Table 5-4. The calibrated values for each unit were based on results from local aquifer tests, descriptions of the different lithologies and regional knowledge of the hydrogeological setting. The hydraulic conductivity of the alluvial deposits was assumed to be uniform for the study area as based on borehole logs and field observations of a mixture of clayey and sandy sediments. A k_h/k_v factor of 1 was used for the alluvial deposits and 10 for the fractured rock lithologies.

Table 5-4: steady State Model Calibrated Hydraulic Conductivities

Lithological Unit	Layer(s)	k_h (m/d)	Unit T (m^2/d)
Sediments	1-2	13.2	66
Meta-greywacke - weathered	1-4	1.2	30
Granite - weathered	1-4	0.52	13
Schist - weathered	1-4	0.82	21
Pegmatite - weathered	1-4	6	150
Dyke - weathered	1-4	0.33	8.3
Fault/structure - weathered	1-4	1.2	30
Meta-greywacke - highly fractured	5-6	0.21	6.3
Granite - highly fractured	5-6	0.08	2.4
Schist - highly fractured	5-6	0.08	2.4
Pegmatite - highly fractured	5-6	0.4	12

Lithological Unit	Layer(s)	k_h (m/d)	Unit T (m^2/d)
Dyke - highly fractured	5-6	0.024	0.7
Fault/structure - highly fractured	5-6	0.08	2.4
Meta-greywacke - low fractured	7-8	0.08	20
Granite - low fractured	7-8	0.08	20
Schist - low fractured	7-8	0.08	20
Pegmatite - low fractured	7-8	0.2	49
Dyke - low fractured	7-8	0.08	20
Fault/structure - low fractured	7-8	0.008	1.6

5.2.1.7. Other Model Parameters: Recharge

Based on background information and results from the calibration process, the following was derived:

- Recharge to the area is between 0.08 and 1% of MAP;
- Higher recharge was assigned for the elevated area and sedimentary deposits, ranging between 0.4 and 1% of MAP; and
- Lower recharge was assigned for the weathered lithologies for the remainder of the model, ranging between 0.08 and 0.1% of MAP.

5.3. Sensitivity Analysis

A sensitivity analysis was carried out on the calibrated model. The purpose of the sensitivity analysis was to quantify the uncertainty in the calibrated model caused by the uncertainty in the estimates of aquifer parameters. During the sensitivity analysis, horizontal conductivity and recharge were assessed. Parameters that model results are most sensitive to can be seen in Figure 5-5. Results of the sensitivity analysis indicate that the water levels in the model are mainly sensitive to changes in horizontal hydraulic conductivities of the highly fractured marble and pegmatite units, and to a lesser extent in highly fractured meta-greywacke, dyke and granite units and low fractured meta-greywacke, schist and marble units.

Based on these results, it is recommended that continuous groundwater monitoring should include the bedrock units in close proximity and surrounding the abstraction holes with focus on monitoring boreholes intersecting the units above. Continued time series groundwater level data from selected groundwater monitoring boreholes will most benefit future model updates

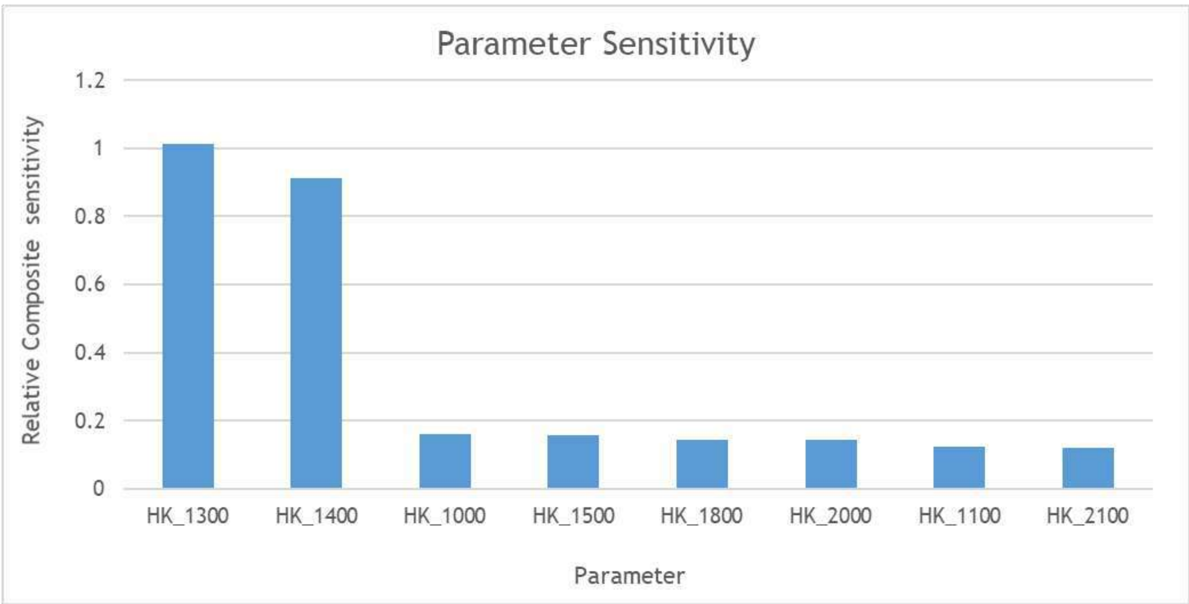

Figure 5-5: Model Parameter Relative Composite Sensitivity

5.4. Simulated Water Levels and Flow Direction

The simulated groundwater levels for the pre-abstraction situation are shown in Figure 5-6. The groundwater levels show the general east to west flow direction of groundwater from the elevated area underlain by marble units towards the outflow point of the Uis River. This aligns with the topographical gradient of the area and general drainage patterns. The lowest groundwater levels are located at the westernmost end of the model representing the river outflow.

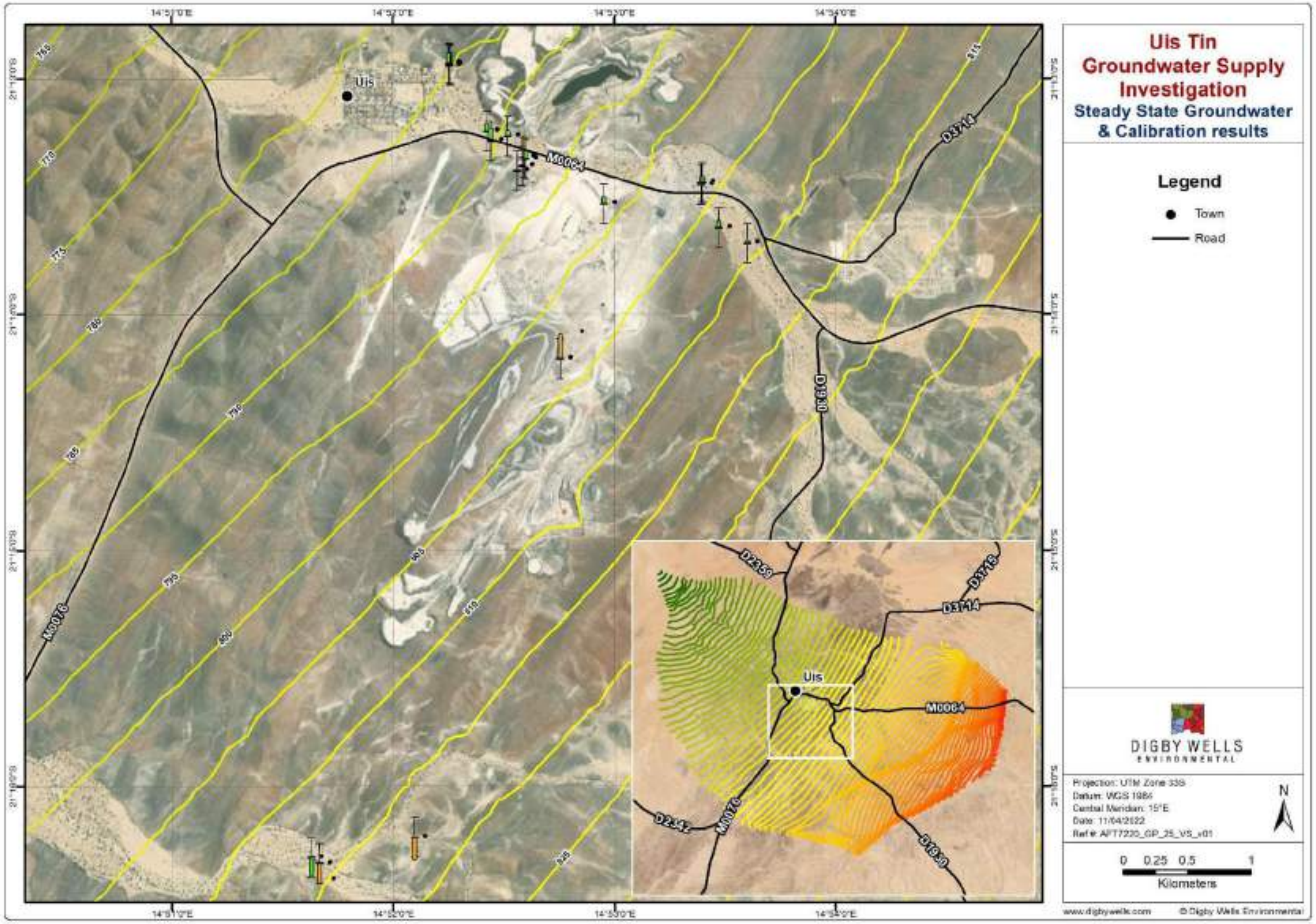

Figure 5-6: Steady-State Groundwater Levels and Calibration Results

5.5. Model Outcomes

The numerical model was used to assess the drawdown impacts associated with abstracting the average sustainable yield (Table 3-8) for each of the water supply boreholes for the Phase 1 Stage II Life of Mine (LoM) of 18 years. The numerical model was calibrated using the transient abstraction data and the simulated drawdowns (within the water supply boreholes which are currently being monitored) are deemed to be representative of the current drawdowns measured. The simulated drawdowns are compared with the observed groundwater drawdowns in Figure 5-7 to Figure 5-11 and show a general fluctuation in drawdowns over time.

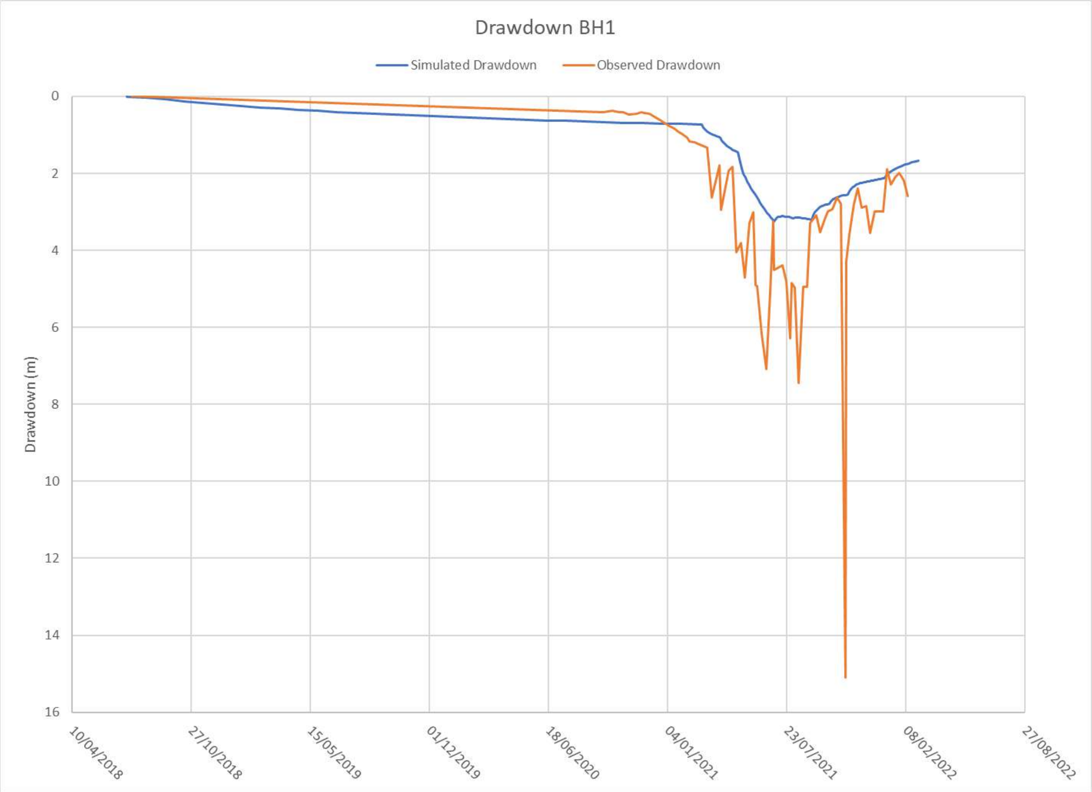

Figure 5-7: Simulated Drawdowns in BH1

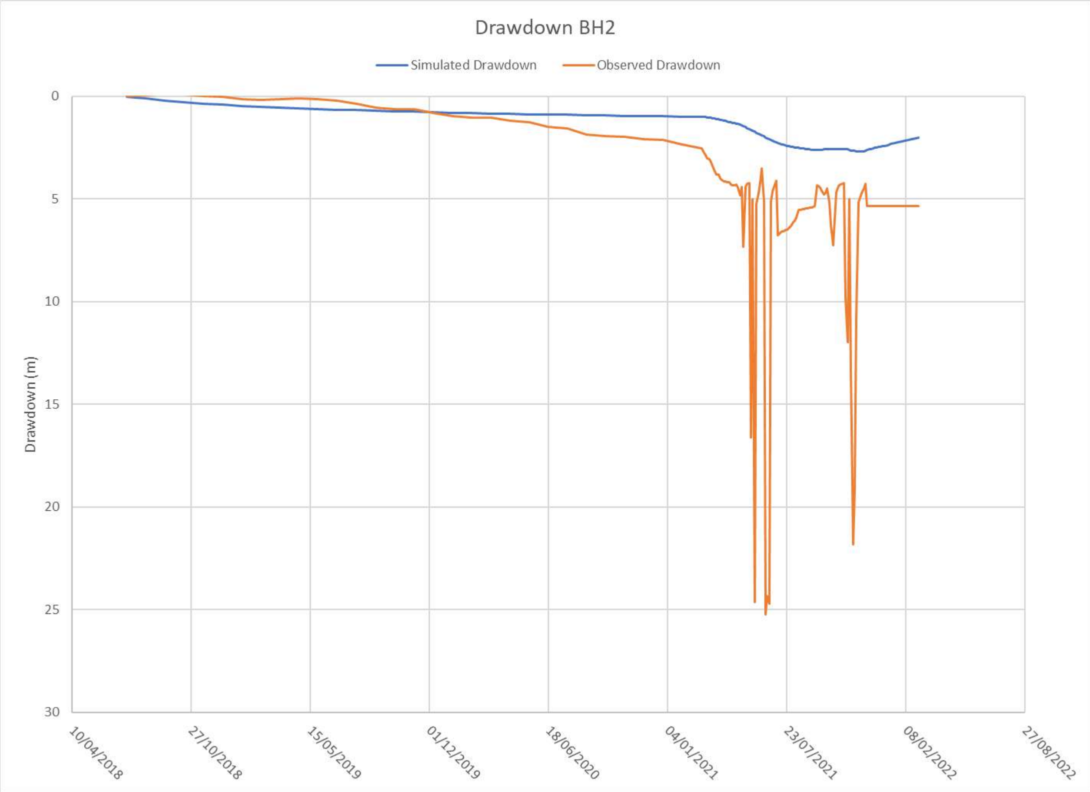

Figure 5-8: Simulated Drawdowns in BH2

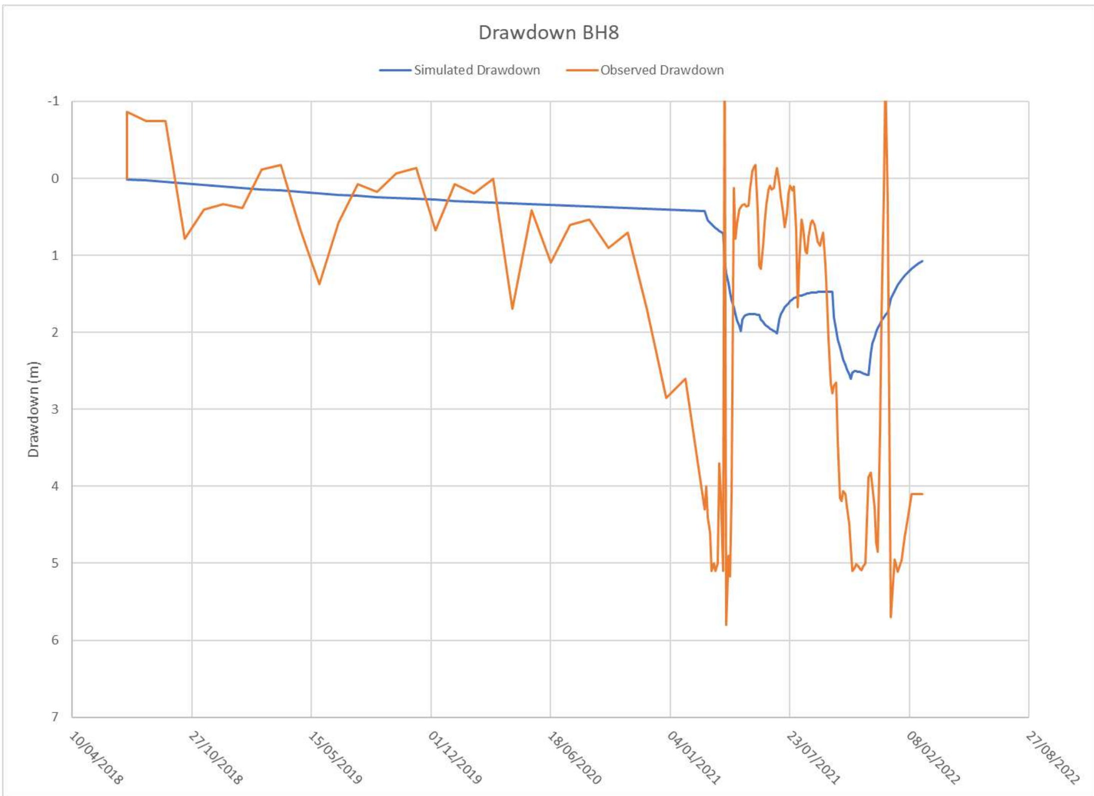

Figure 5-9: Simulated Drawdowns in BH8

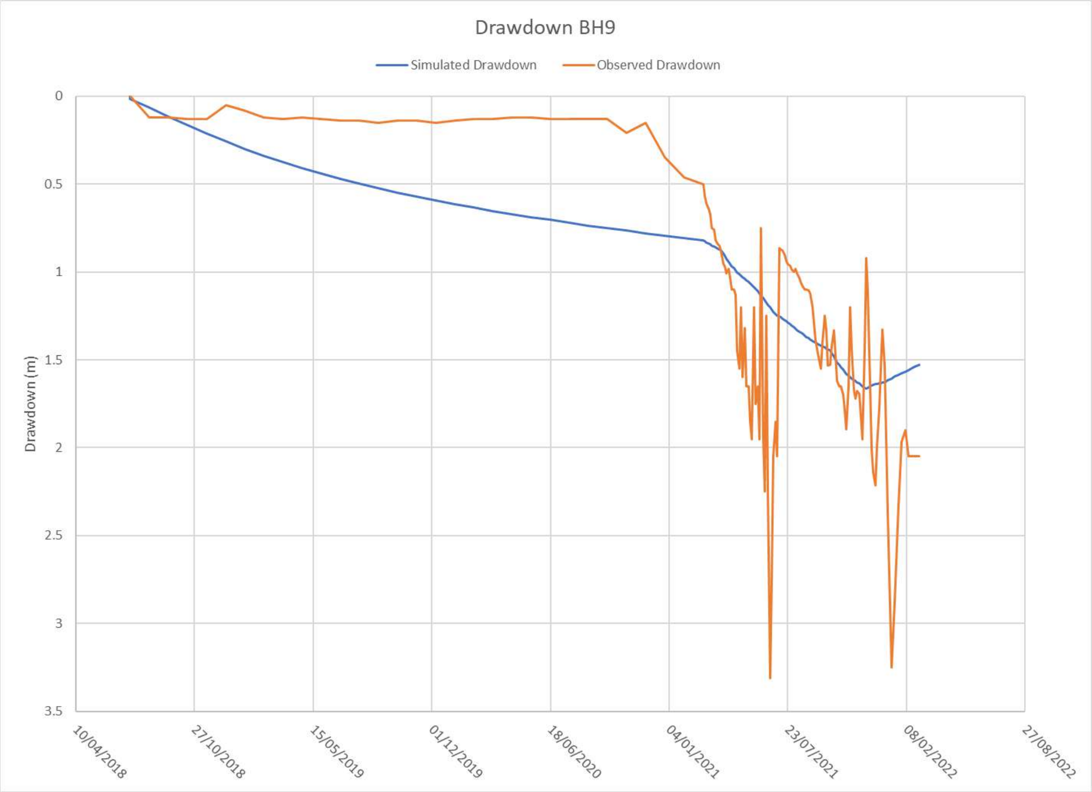

Figure 5-10: Simulated Drawdowns in BH9

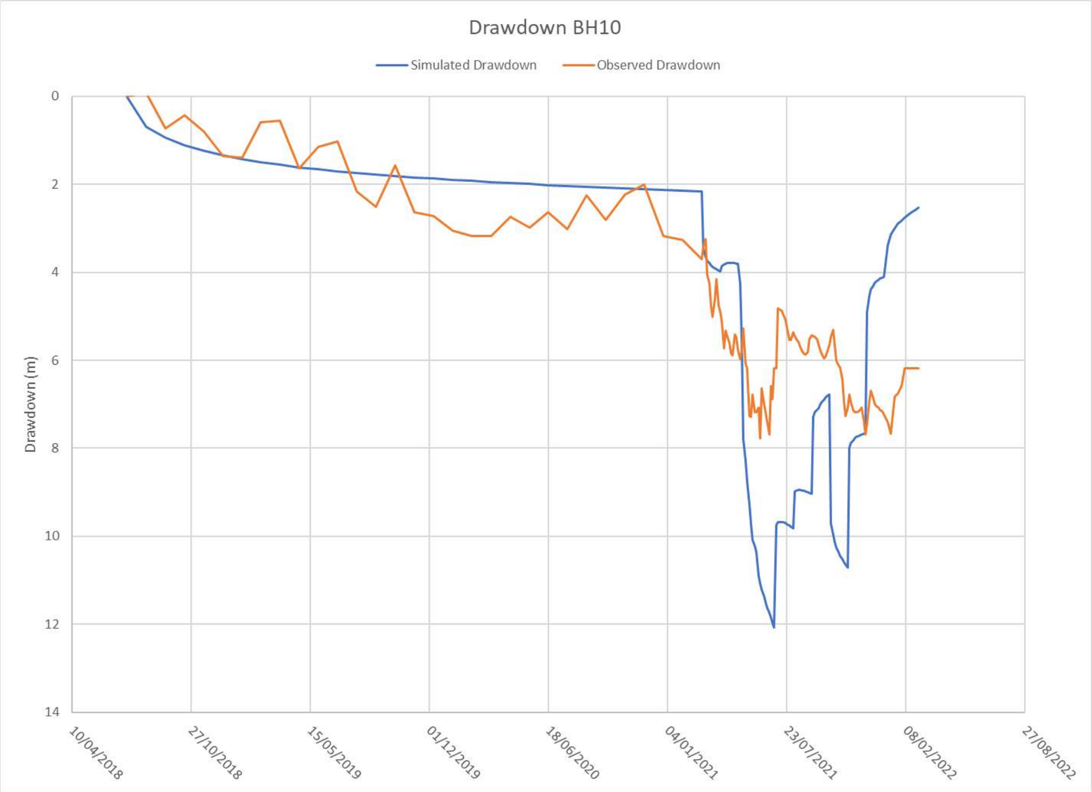

Figure 5-11: Simulated Drawdowns in BH10

The abstraction for the Phase 1 Stage II requirements begins from the current groundwater levels (Figure 5-13) simulated for the Uis River Catchment which has already been impacted by abstractions for the Uis Tin Mine and by third-party groundwater users (Section 2). The cumulative drawdown for the Uis Tin Mine water supply boreholes and third-party groundwater users is shown in Figure 5-14, and represents a worst-case scenario with regards to the drawdown in the catchment.

The drawdown impacts associated with pumping the average sustainable yield from each of the water supply boreholes for a period of 18 years will extend to a maximum of ~6.5 km from the Uis Tin Mine and have a maximum regional drawdown of ~4.5 m in 2040 when compared to the current situation. The drawdown impacts will recover once abstraction activities cease, however based on the low recharge the impact may remain for an extended period of time (Table 5-5). The drawdown impacts have been assessed as minor using the impact assessment methodology defined in Appendix D.

5.5.1. Recharge Scenarios

The numerical model was run with different recharge inputs to determine the effect variable recharges to the simulated groundwater levels. The following recharge scenarios were modelled:

- Average monthly recharge rates;
- Average yearly recharge rates (Figure 5-12);

Simulating the monthly and annual recharge rates for the pre-abstraction period (1979 to 2019) showed a variation in simulated groundwater levels by between 0.15 – 5 m. Based on these results it is possible that the groundwater levels could fluctuate by 5 m as a result of changes in recharge over the proposed LoM which will need to be accounted for within the anticipated drawdowns associated with the abstraction boreholes.

Table 5-5: Abstracting Groundwater for Water Supply

Dimension	**Rating**	**Motivation**	**Significance**
Activity and Interaction: Abstracting groundwater for water supply purposes			
Impact Description: Drawing down the groundwater levels around the Uis River and Southern wellfields, reducing aquifer yields to third-party groundwater users.			
Prior to Mitigation/Management			
Duration	6	The impact will remain for some time after the life of mine.	Minor (negative) - 51
Extent	4	The impact extends beyond the site.	
Intensity	3	Moderate loss and/or effects to the physical resource.	
Probability	7	Definite	
Nature	Negative		
Mitigation/Management Actions			
• Implement best practice and investigate new technologies to use water as efficiently as possible during the LoM; • Collect stormwater runoff (when available and where possible); • Manage abstraction from the boreholes with a water management plan; • Implement regular borehole maintenance to improve the yields from the boreholes (reduce scaling, fouling, precipitation of oxides and presence of roots within the boreholes); • Drill additional (or locate existing) water supply boreholes near the mine, to supplement water supply during borehole maintenance periods; • Continue monitoring the groundwater levels on a weekly basis to monitor for any changes to the predicted drawdowns; • Monitor abstraction rates and volumes from the water supply boreholes; • Monitor rainfall events on site; and • Monitor the water quality from the water supply boreholes on a quarterly basis to monitor for any changes in quality which may indicate if any changes are occurring in the aquifer.;			
Post-Mitigation			
Duration	6	The impact will remain for some time after the life of mine.	Minor (negative) - 48
Extent	3	The impact extends beyond the site.	
Intensity	3	Moderate loss and/or effects to the physical resource.	
Probability	7	Definite	
Nature	Negative		

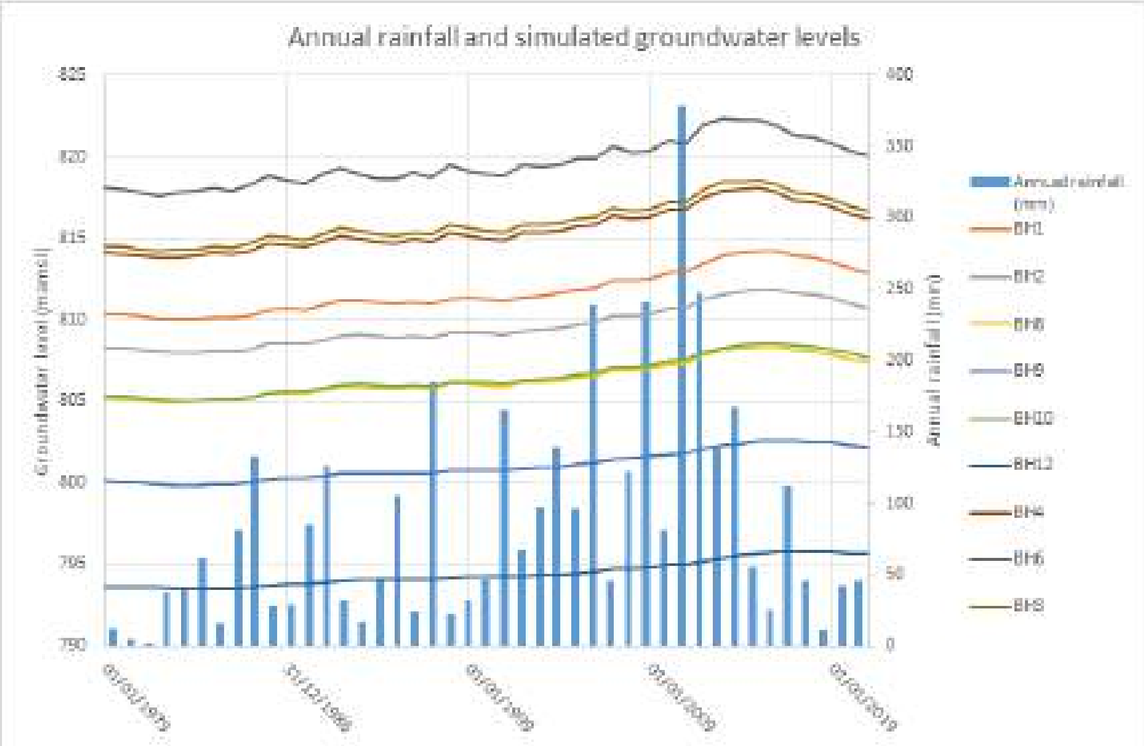

Figure 5-12: Pre-Abstraction Simulated Groundwater Levels and Annual Rainfall Inputs

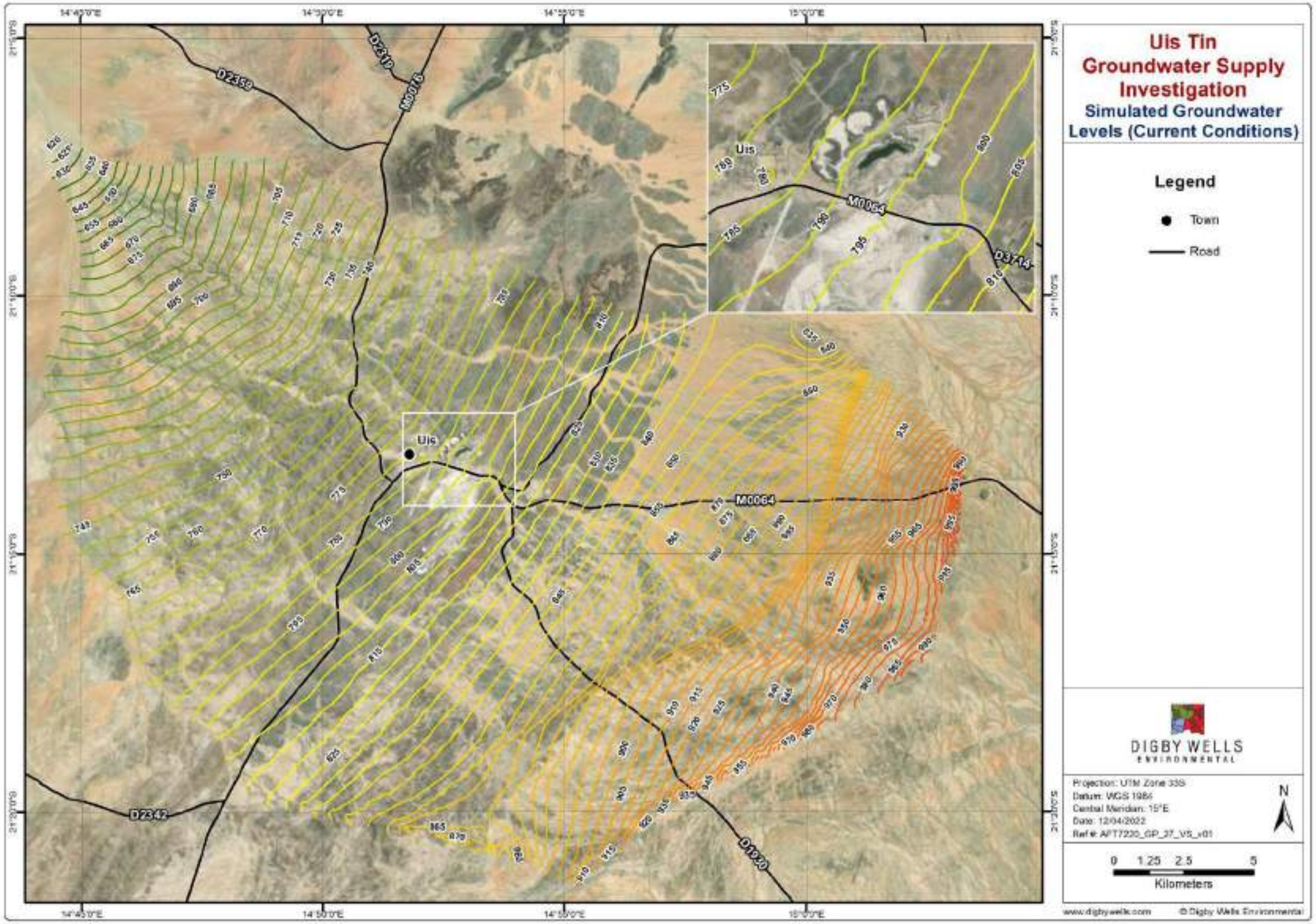

Figure 5-13: Simulated Groundwater Levels (Current Conditions)

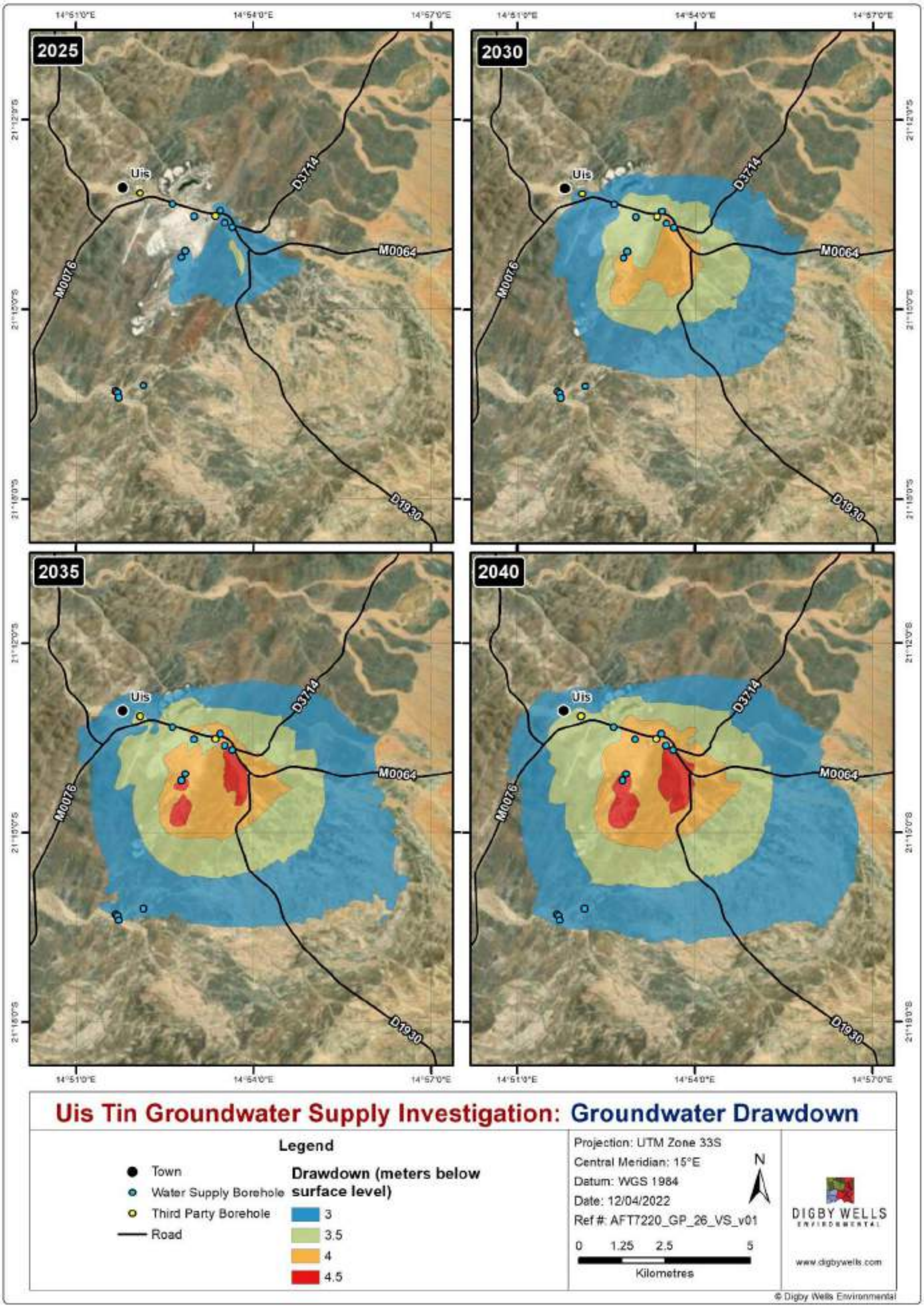

Figure 5-14: Simulated Drawdown Cones for 2025, 2030, 2035 and 2040

6. Water Management Plan

The objective of the Water Management Plan is to ensure a consistent supply of water to the processing plant whilst not depleting the groundwater resource for other third-party groundwater users. The availability of water is dependent on a climate change, increasing demand, lowered water tables and environmental degradation and it is therefore important to manage the groundwater resource so that it may sustain long term use. The Phase 1 Stage II expansion will require ~354 m^3/d (18 m^3/hr for ~590 hours per month) for 18 years based on the reserve LoM, which equates to a total volume of 2 293 920 m^3.

6.1. K5 Pit Water Use

AfriTin plan to continue mining from the K5 pit area in the future and would require that the pit be drained before mining commences but the timeline for this has not been confirmed. A bathymetric survey undertaken for the K5 pit indicates that the current volume of water within the pit is 190 634 m^3 (Strydom & Associates, 2022). The current volume in the K5 pit can provide ~ 8% of the total volume required, which would be able to supply the processing plant for ~1.5 years.

By supplementing the water supply to the plant with the water stored in the K5 pit the demand from the water supply boreholes can be reduced allowing time to clean the current water supply boreholes. Abstractions from the pit however could potentially influence the yields of the boreholes located nearby to the K5 pit and this will need to be monitored once dewatering activities commence. It is recommended to plan the dewatering of the K5 pit as far as possible in advance so that the available water within the pit can be used by the plant instead of being discharged to the environment.

AfriTin could consider constructing an emergency water storage area near to the plant which is covered to minimise losses from evaporation. The capacity of the tanks within the storage area should be able to supply a week's water supply to the plant (~2 700 m^3) that can be used in case of emergencies or to supplement the plant during borehole maintenance periods.

6.2. Water Supply Borehole Use

The current water supply boreholes have a combined 18.7 m^3/hr average sustainable yield which can just sustain the Phase 1 Stage II expansion requirements, however the water supply from the boreholes will need to be monitored and managed to prevent depleting the groundwater resource or reducing the efficiency of the borehole as the boreholes will need to be operated for ~20 hours per day every day to meet the plant requirements. The proposed management plan for the water supply boreholes is provided in Table 6-1 and Figure 6-1.

Table 6-1: Water Supply Borehole Management Plan

Water Supply Borehole	Surface Elevation (mamsl)	Operational Times (hours per day)	Currently Used	Sustainable Yield Pump Rate (m^3/hr)	Pump Rate (m^3/d)	Pump Rate (m^3/month)	Current Static / Dynamic GWL (mbgl)[19]	Anticipated Dynamic GWL (mbgl)[20]	Monitoring Requirements	Operational and Maintenance Requirements	
BH1	829	19.7	Yes	0.4	7.9	236	24.2	34.9929.2	• Monitor daily abstraction rates and volumes; • Monitor rainfall on site; • Monitor groundwater levels in active abstraction boreholes on a weekly basis; • Monitor groundwater levels in unused boreholes on a quarterly basis; and • Monitor water quality on a quarterly basis.	4 hours per day have been allocated to allow water levels to recover in the water supply boreholes. This can be used as a buffer (if needed) to conduct maintenance on boreholes, pumps and/or the reticulation system. Maintenance on the boreholes and/or pumps should be scheduled if there is a drop in the borehole yield or the water levels begin to drop significantly compared with the established trend. Boreholes should be cleaned every 2 years unless the monitoring data indicates a higher frequency is required. The monitoring data collected must be used to recalibrate the numerical model once every two years to confirm the impact to the resource and allow early detection of any water supply issues.	
BH2	827	19.7	Yes	0.2	3.9	118	30.0	42.035.			The efficiency of this borehole has declined since 2018. This borehole must be cleaned and retested to verify if the yield can be improved. This borehole may need to be cleaned on an annual basis to maintain yields based on the observed aquifer test response. Monitoring results will confirm this. Consider casing this borehole to reduce the risk of collapse.
BH3	839	19.7	No	0.3	5.9	177	17.1	28.8822.1			Consider casing this borehole to reduce the risk of collapse.
BH4	838	19.7	No	1.0	19.7	590	21.9	35.2226.9			
BH6	845	19.7	No	1.0	19.7	590	17.4	29.3322.4			
BH8	829	19.7	Yes	8.5	167.2	5015	37.0	49.9942.0			
BH9	825	19.7	No	0.9	17.7	531	34.5	49.7739.5			Clean this boreholes of the roots currently growing into it and casing to prevent roots blocking the borehole and losing the installed pump. This borehole had oxide deposits on the existing pump and may need to be cleaned on an annual basis to maintain yields and the pump condition. Monitoring results will confirm this.
BH10	824	19.7	Yes	4.0	78.7	2360	33.6	44.8838.6			
BH11	829	19.7	No	1.4	27.5	826	41.3	53.9946.3			Case this borehole to reduce the risk of collapse.
BH12	811	19.7	No	1.0	19.7	590	31.9	45.4436.9			
A	Estimate yield (6.5 m^3/hr)									Locate and aquifer test these boreholes as an alternative water supply borehole to supplement the plant during periods of maintenance on the existing boreholes or should the efficiency of the current boreholes reduce.	
B	Estimate yield (12.2 m^3/hr)										
C	Estimate yield (5.0 m^3/hr)										

[19] Current groundwater level (GWL) is based on the static water level at the time of aquifer testing as a worst-case scenario.

[20] The anticipated dynamic GWL in the boreholes is calculated based on a comparative drawdown with the aquifer testing data with an additional 5 m added to accommodate potential fluctuations in recharge rates and 4.5 m to accommodate regional drawdown impacts.

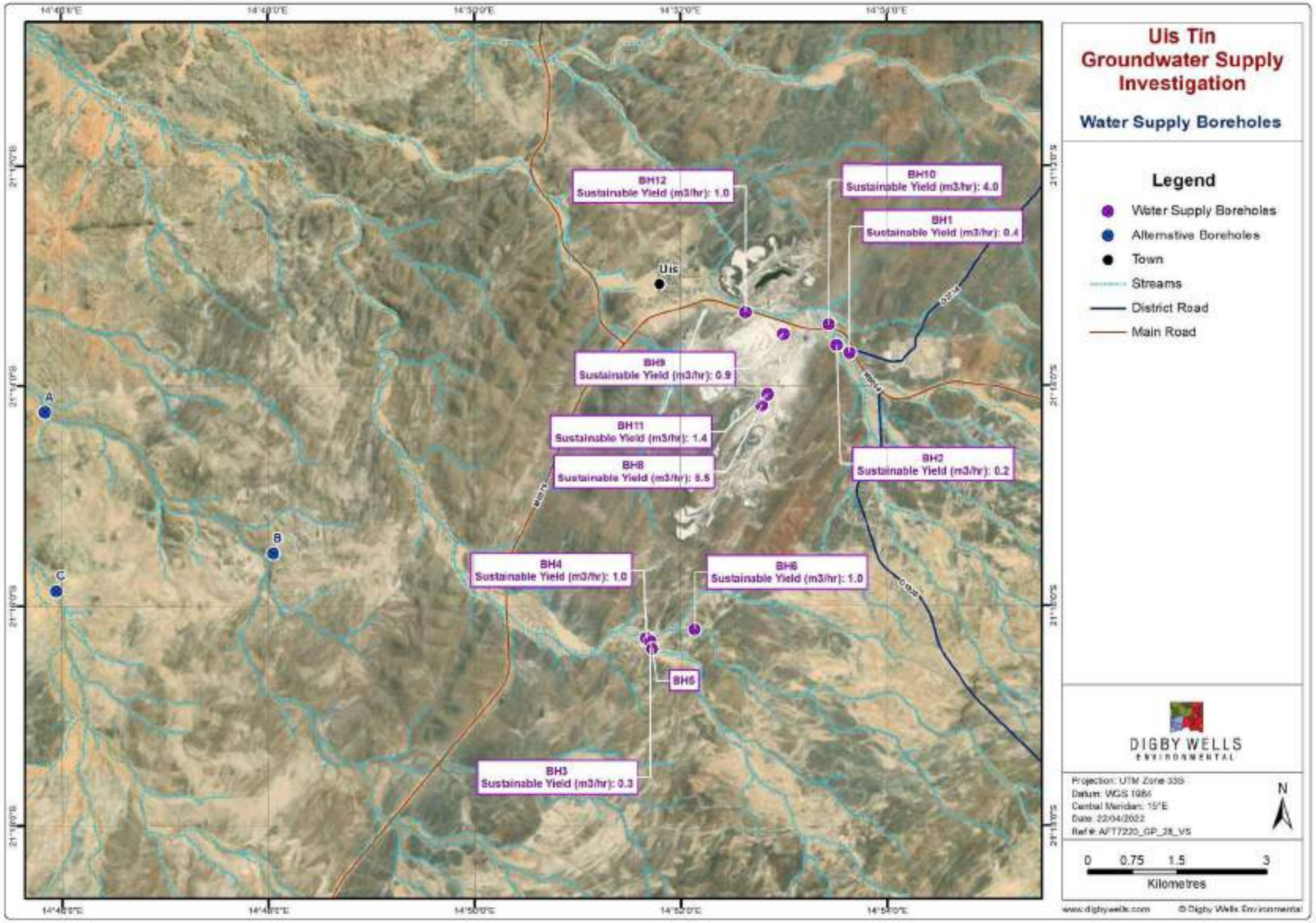

Figure 6-1: Water Supply Boreholes and Potential Alternative Boreholes

6.2.1. Additional Abstraction Boreholes

It is recommended to locate or drill additional boreholes to supplement the water supply to the plant (during borehole maintenance periods) or supplement the current abstraction boreholes in case the efficiency of the current water supply boreholes deteriorates.

Any new water supply boreholes should be drilled to the following specifications:

- 12-inch (305 mm) open hole drilling to 5 mbgl;
- Install 11-inch (279 mm) mild steel casing to 5 mbgl;
- 10-inch (254 mm) open hole drilling to 80 – 100 mbgl;
- Install 8-inch (203 mm) PVC casing with screened sections across intersected fractures;
- Fill the annulus with a gravel pack to 5 m above the shallowest screened section;
- Install a grout / bentonite seal above the gravel pack, backfill the annulus with borehole risings;
- Install a 4-inch (102 mm) submersible pump and include a motor cooling sleeve where necessary;
- Install 2-inch (50.8 mm) uPVC rising main to the top of the well; and
- Construct steel well headworks with flange to connect to the water supply system.

If boreholes intersect higher yielding fractures (with blow yields >20 m^3/hr), the borehole must be reamed to a larger diameter to accommodate a large pump size. After the construction of the new boreholes are completed, the boreholes must be aquifer tested to verify the sustainable yields. A four (4) hour step test with forty-eight (48) hour constant discharge test should be performed on the boreholes. After aquifer testing has been completed groundwater quality samples should be taken to a lab for analysis to determine the groundwater quality.

6.2.2. Borehole Maintenance

The ability of a borehole to perform optimally can be reduced if sediment builds up in the borehole (i.e., sediments entering the borehole through damaged casing or screens, or precipitation of calcium and iron) or high levels of iron, calcium and magnesium form precipitates which block equipment or casing screens.

The monitoring data will help with determining when boreholes will need to be cleaned (or maintained) so that it can operate optimally and prolong the lifespan of the pumps. It is recommended that boreholes be cleaned every two (2) years unless the monitoring data indicates more frequent cleaning is required (colour changes to brown or red, yields decrease, or water levels drop).

The following borehole maintenance is recommended:

- Using high pressure compressor to flush the sediment and debris from boreholes;
- Brushing (sweeping) the borehole casing (or side walls) with brushes to remove build-up of slime (produced by iron bacteria) or deposits from the casing screens;
- Chemical additives could be used provided this doesn't interfere with the water chemistry needed in the plant or surrounding water supply boreholes;
- Roots could be removed by reaming the borehole, using a wiper tool or welding steel blades onto a heavy rod. Sharper blades should be positioned on the lower portion to assist with cutting roots when the rod is being lowered and blunter blades can be positioned higher up to assist with grabbing the loose roots when pulling the rod out of the borehole. An auger-type fitting may also be an option. The borehole will need to be cleaned regularly to prevent the roots regrowing;
- Steel casing will corrode over time, and it is recommended to install PVC casing in newly drilled boreholes (or uncased) or replace the steel casing in existing boreholes to prolong the life of the borehole;
- Complete a downhole camera survey (in uncased boreholes) to assess if the fractures are blocked which may need to be flushed, brushed or redrilled to a slightly larger diameter to try clear surface deposits on the borehole walls which may be blocking yields.

6.2.3. Groundwater Monitoring

Groundwater monitoring will assist the mine with determining any changes in the aquifer sources (with the quality results) as well as the borehole efficiency (with the abstraction rates, yields and groundwater levels). The collected monitoring data can be used to recalibrate numerical model updates which will allow the mine to detect any changes with the potential water supply in a timely so that an alternative arrangement can be implemented. The following parameters must be monitored:

- Rainfall must be measured daily at the project site. This data can be compared with the groundwater level data to determine recharge responses to the groundwater aquifer;
- Abstraction rates and volumes must be measured on a daily basis. This will be used to track requirements from the plant and the sustainable use of the water supply boreholes. Changes in the demand from the plant above the 18 m^3/hr requirement or ability of the water supply boreholes to produce the sustainable yields, will require additional water supply boreholes to be incorporated into the water supply network;
- Groundwater levels must be measured on a weekly basis (in active water supply boreholes) and on a quarterly basis (in unused water supply boreholes). The groundwater levels can be used to monitor if the yields abstracted from the boreholes are sustainable or if scaling or fouling of the borehole may be occurring. Water levels

that start dropping significantly compared to established trends could indicate that maintenance is required to remove scale and/or oxide deposits from the borehole:

  - Groundwater level measurements which change by more than 5 m between readings will need to be verified as correct with an additional measurement. Comments should be included with the verified measurement as to the cause of the change in water levels;

- Water quality must be sampled and analysed on a quarterly basis. This will assist in establishing if any changes in the aquifer water sources are occurring as a result of abstraction. Samples must be submitted to an accredited laboratory for analysis. The following constituents must be included in the water quality analysis as a minimum (Table 6-2):

  - Taking note of the water colour (becomes brown or reddish) in the samples could also assist with determining if the borehole will need to be cleaned.

Table 6-2: Water Quality Monitoring Constituents

pH	Calcium	Fluoride
Electrical Conductivity	Magnesium	Sulphate
Total Dissolved Solids	Sodium	Nitrate
Total Alkalinity	Potassium	Iron
Total Hardness	Chloride	Manganese

6.3. Water Management Recommendations

The following recommendations are required to reduce the groundwater abstraction risk for the mine or manage the groundwater resource:

- Integrate the groundwater outcomes into the site water balance and keep the water balance updated throughout the LoM;
- It is recommended to plan the dewatering of the K5 pit well in advance so the dewatered volumes can be used to meet the plant requirements instead of being discharged to the environment. The water in the pit has higher concentrations compared to the groundwater samples which may dictate how much of the pit water can be used during a month (if this needs to be diluted with clean or groundwater contributions). The water quality requirements of the plant will therefore need to be defined as soon as possible or the establishment of a water treatment plant could be considered;
- Establish a covered water storage area nearby to the plant which contains water storage tanks with a minimum capacity of 1 week (~2 700 m^3) which can provide an emergency water source to the plant;

- As the water supply boreholes just meet the demand requirement for the plant, it is recommended to include additional water supply boreholes into the network to supplement yields during borehole maintenance periods (once the K5 pit is dewatered) or supplement abstraction in case the efficiency of the current water supply boreholes deteriorates;
- These additional boreholes should be established as soon as possible to prevent any water supply delays to the plant and should preferably be located outside of the Uis River Catchment to reduce the cumulative drawdown impacts within this catchment. Based on the available information there are potentially three (3) boreholes located within a ~13 km radius from the mine which have a combined estimated yield of 23.7 m^3/hr. If these boreholes can be located and used, the sustainable yield would need to be assessed with aquifer tests;
- Where processes allow for it, water used in the plant should be recovered and reused as much as possible;
- Reticulation system must be maintained to prevent leaks and minimise losses of water from the system;
- Recover and reuse water from the Uis wastewater treatment works to supplement the plant requirements (if possible);
- Collect and store rainwater in pit areas (when not operational) as an additional temporary source of water, which could supplement the supply from the water supply boreholes when available;
- AfriTin are currently allowed to abstract a total of 75 000 m3/a (permit No. 11429) (AfriTin Mining Limited, 2021). The permitted abstraction volume will need to be increased for the Phase 1 Stage II abstraction requirements

7. Conclusion

The following conclusions are drawn from the hydrogeological assessment:

- The yield demand for the Phase 1 Stage II expansion of 18 m^3/hr can be provided by the existing water supply boreholes which have a combined sustainable yield of 18.7 m3/hr based on the interpreted aquifer test results;
- The groundwater quality is not suitable for human consumption, however it can be used as raw water supply in the plant;
- Based on the numerical model simulations the water supply abstractions is deemed to be sustainable, however the water supply abstractions will stress the aquifer due to the low recharge potential of the region. The cumulative abstractions for the proposed 18-year Life of Mine will create a drawdown cone with a maximum extent of ~6.5 km and a drawdown of ~4.5 m;

- Should there be any significant increases in demand from the aquifer (by the mine or third-party groundwater users), draughts or climate changes there may be an impact to the long-term sustainable yield of the wellfield;
- AfriTin will need to install additional boreholes for the Phase 1 Stage II expansion to enable maintenance and to mitigate any losses in yield from the existing water supply boreholes;
- A groundwater monitoring programme has been recommended to assist AfriTin with managing their groundwater resource. Although it is recommended that boreholes be cleaned every two (2) years, any drop in yield or increased drawdown within the water supply borehole can indicate that maintenance is required;
- The groundwater monitoring will also assist AfriTin with determining if there are any changes occurring within the aquifer which may require intervention;
- AfriTin will need to investigate alternative water sources for the planned Phase 2 expansion once water demands for this phase have been confirmed. Abstracting higher yields of groundwater from the possible alternative groundwater wellfields could potentially have significant impacts to the groundwater aquifer in the region. Alternative water supply options such as piping water from the Orano Desalination plant or directly from the sea should also be considered for the Phase 2 expansion.

8. Recommendations

The following recommendations are proposed:

- Integrate the groundwater outcomes into the site water balance to assist with the efficient management of water resources on site and identify and minimise water losses from the system;
- Implement the monitoring, operational and maintenance requirements as outlined in the Water Management Plan (Section 6);
- Schedule borehole maintenance every 2 years unless the monitoring data (yield vs drawdown) indicates more frequent cleaning is required (Section 6.2);
- Locate or drill alternative boreholes to replace the existing boreholes if yields cannot be improved or maintained or to supplement water supply during borehole maintenance periods (after the K5 pit has been drained);
- Establish a covered water storage area nearby to the plant which contains water storage tanks with a minimum capacity of 1 week (~2700 m^3) which can provide an emergency water source to the plant;
- AfriTin will need to amend their permitted abstraction volume to account for the required 18 m^3/hr (127 440 m^3/a) required by the plant for the Phase 1 Stage II expansion;

- Locate third-party groundwater users within a 10 km radius of the mine wellfields and confirm their current abstraction requirements and planned future abstraction requirements;
- It is recommended to plan the dewatering of the K5 pit well in advance so the dewatered volumes can be used to meet the plant requirements instead of being discharged to the environment. The water in the pit has higher concentrations of calcium, magnesium, sodium, potassium chloride, sulphate, iron, manganese and electrical conductivity compared to the groundwater samples which may dictate how much of the pit water can be used during a month (if this needs to be diluted with clean or groundwater contributions). The water quality requirements of the plant will therefore need to be defined as soon as possible or the establishment of a water treatment plant could be considered;
- The numerical model must be recalibrated every 2 (two) years to incorporate the latest monitoring data as well as any changes to the water supply network or plant yield requirements. The model will be an asset to AfriTin to assess any changes which could affect the water supply for the project;
- The numerical model can be refined in future updates to simulate climate change responses to the expected rainfall volumes over the life of mine. The IPCC report indicates that drought events in Southern Africa (caused by the El Nino oscillation) are predicted to become more frequent and intense, which could affect the recharge potential to aquifers in the region.

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Appendix A: Methodology

Aquifer testing

A subcontractor (Hammerstein Mining and Drilling) was appointed to undertake the aquifer testing under the supervision of Digby Wells. 48-hour constant discharge (CDT) aquifer pump and recovery tests were carried out on existing boreholes. These tests will be used to determine aquifer parameters that will serve as input into the groundwater model but will also provide input to determine the sustainable yield of each borehole.

The following methodology was used for the CDT tests:

- Boreholes in each cluster were switched off prior to undertaking the aquifer tests in each cluster:
  - Cluster 1: BH1, BH2, BH10;
  - Cluster 2; BH9, BH12;
  - Cluster 3; BH8, BH11;
  - Cluster 4: BH3, BH4, BH5, BH6
- A 30-minute calibration test was undertaken on boreholes which had previously been aquifer tested in 2018 to confirm the previous rates:

Borehole	Previous CDT Rate (m3/hr)	Previous CDT Duration (hours)
BH1	5	8 (recovery in 8 hours)
BH2	6	8 (recovery in 8 hours)
BH3	2	8 (recovery in 8 hours)
BH4	3	8 (recovery in 8 hours)
BH5	2.5	8 (recovery in 8 hours)
BH6	6	8 (recovery in 8 hours)
BH8	17.5	24 (recovery in 24 hours)
BH9	6	8 (recovery in 8 hours)
BH10	17.5	24 (recovery in 24 hours)
BH11	3 (Blow Yield Estimate)	Not tested
BH12	-	Not tested

- A step drawdown and recovery test were undertaken on boreholes which weren’t previously aquifer tested (BH11 and BH12). The step test comprised of three 1-hour long steps with increasing rates followed by recovery;
- Following the calibration or step test 48-hour constant discharge test (yield permitting) on each borehole followed by a recovery test (48-hours or to 90% of initial level);
- During the CDT test a water sample was collected every 12-hours and submitted to an Analytical Laboratory in Windhoek Namibia for Analysis.

Appendix B: Laboratory Certificates

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree

Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave

PO Box 86782, Windhoek, Namibi

TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH2-1
Date of sampling	3 Dec 2021,16h00
Test item number	I212234/1

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.1**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**651**	**mS/m**	D	150	300	400	
Turbidity	**26**	**NTU**	D	1	5	10	
Total Dissolved Solids (calc.)	**4126**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**395**	**mg/l**					
Total Hardness as $CaCO_3$	**1825**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1084**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**741**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1383**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**992**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**17**	**mg/l**	B	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**791**	**mg/l**	C	100	400	800	2000
Potassium as K	**32**	**mg/l**	A	200	400	800	
Magnesium as Mg	**180**	**mg/l**	C	70	100	200	500
Calcium as Ca	**434**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**0.06**	**mg/l**	B	0.05	1.0	2.0	10
Iron as Fe	**2.2**	**mg/l**	D	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, >6.5 and <7.5=stable			
Corrosivity ratio	**7.6**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms S. Rügheimer

Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
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Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

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Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

Approved Technical Signatory
Ms S. Rügheimer

Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree

Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave

PO Box 86782, Windhoek, Namibi

TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH2-3
Date of sampling	4 Dec 2021, 06h42
Test item number	I212234/2

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.7**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**652**	**mS/m**	D	150	300	400	
Turbidity	**0.30**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4195**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**395**	**mg/l**					
Total Hardness as $CaCO_3$	**1813**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1064**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**749**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1452**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1002**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**19**	**mg/l**	B	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**778**	**mg/l**	C	100	400	800	2000
Potassium as K	**32**	**mg/l**	A	200	400	800	
Magnesium as Mg	**182**	**mg/l**	C	70	100	200	500
Calcium as Ca	**426**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.4**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.0**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.8**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
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Group B: good quality water
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Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Windhoek
info@analab.com.n
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71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
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Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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OUR QUALITY IS IN THE DETAIL

Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22
Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH2-4
Date of sampling	4 Dec 2021, 16h10
Test item number	I212234/3

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**652**	**mS/m**	D	150	300	400	
Turbidity	**0.55**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4096**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**400**	**mg/l**					
Total Hardness as $CaCO_3$	**1817**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1084**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**733**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1406**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.2**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**932**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**19**	**mg/l**	B	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**790**	**mg/l**	C	100	400	800	2000
Potassium as K	**31**	**mg/l**	A	200	400	800	
Magnesium as Mg	**178**	**mg/l**	C	70	100	200	500
Calcium as Ca	**434**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.4**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Windhoek
info@analab.com.na
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.na
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

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Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
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Windhoek
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street
Walvis Bay
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibia

Analytical Laboratory Services
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TEST REPORT

To:	**Digby Wells Environmental SA**		
	48 Grosvenor Road	Date received:	15/Dec/21
	Bryanston	Date analysed:	14 Jan - 8 Feb 2022
	2191	Date reported:	10/Feb/22
	South Africa		
Attn:	Megan Edwards	Client Reference no.:	AFT 7220
email:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	27117899495	Lab Reference:	I212234
		Enquiries: Ms Manuela Mayer	

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH2-5
Date of sampling	5 Dec 2021, 12h35
Test item number	I212234/4

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**654**	**mS/m**	D	150	300	400	
Turbidity	**0.35**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4120**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**410**	**mg/l**					
Total Hardness as $CaCO_3$	**1810**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1069**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**741**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1429**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.2**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**942**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**17**	**mg/l**	B	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**787**	**mg/l**	C	100	400	800	2000
Potassium as K	**31**	**mg/l**	A	200	400	800	
Magnesium as Mg	**180**	**mg/l**	C	70	100	200	500
Calcium as Ca	**428**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.3**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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Cell +264 81 611 884
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Walvis Bay
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Unit 16, Ben Amathila Ave

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TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH2-6
Date of sampling	5 Dec 2021, 16h00
Test item number	I212234/5

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.97**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**657**	**mS/m**	D	150	300	400	
Turbidity	**0.60**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4148**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**405**	**mg/l**					
Total Hardness as $CaCO_3$	**1820**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1066**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**754**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1406**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.2**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1008**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**13**	**mg/l**	B	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**790**	**mg/l**	C	100	400	800	2000
Potassium as K	**31**	**mg/l**	A	200	400	800	
Magnesium as Mg	**183**	**mg/l**	C	70	100	200	500
Calcium as Ca	**427**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.5**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms S. Rügheimer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.
toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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Cell +264 81 122 158
Unit 16, Ben Amathila Ave

PO Box 86782, Windhoek, Namibi

TEST REPORT

To:	**Digby Wells Environmental SA**			
	48 Grosvenor Road		Date received:	15/Dec/21
	Bryanston		Date analysed:	14 Jan - 8 Feb 2022
	2191		Date reported:	10/Feb/22
	South Africa			
Attn:	Megan Edwards		Client Reference no.:	AFT 7220
email:	megan.edwards@digbywells.com		Quotation no.:	QU-6835
Tel:	27117899495		Lab Reference:	I212234
			Enquiries:	Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH1-1
Date of sampling	7 Dec 2021, 08h56
Test item number	I212234/6

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.5**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**535**	**mS/m**	D	150	300	400	
Turbidity	**1.3**	**NTU**	B	1	5	10	
Total Dissolved Solids (calc.)	**3295**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**525**	**mg/l**					
Total Hardness as $CaCO_3$	**979**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**497**	**mg/l**	B	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**482**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1060**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**1.8**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**561**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**47**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**799**	**mg/l**	C	100	400	800	2000
Potassium as K	**32**	**mg/l**	A	200	400	800	
Magnesium as Mg	**117**	**mg/l**	C	70	100	200	500
Calcium as Ca	**199**	**mg/l**	B	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.5**						
Langelier Index	**0.9**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**4.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
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Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH1-2
Date of sampling	7 Dec 2021, 19h00
Test item number	I212234/7

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.5**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**530**	**mS/m**	D	150	300	400	
Turbidity	**0.35**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**3213**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**550**	**mg/l**					
Total Hardness as $CaCO_3$	**1066**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**572**	**mg/l**	C	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**494**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1037**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**1.9**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**531**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**35**	**mg/l**	C	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**778**	**mg/l**	C	100	400	800	2000
Potassium as K	**31**	**mg/l**	A	200	400	800	
Magnesium as Mg	**120**	**mg/l**	C	70	100	200	500
Calcium as Ca	**229**	**mg/l**	C	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.5**						
Langelier Index	**1.1**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.4**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**3.7**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

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Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
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Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
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PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH1-3
Date of sampling	8 Dec 2021, 05h03
Test item number	I212234/8

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.2**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**532**	**mS/m**	D	150	300	400	
Turbidity	**0.95**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**3210**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**545**	**mg/l**					
Total Hardness as $CaCO_3$	**1073**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**574**	**mg/l**	C	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**498**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1037**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**1.9**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**550**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**34**	**mg/l**	C	10	20	40	100
Nitrite as N	**0.02**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**761**	**mg/l**	C	100	400	800	2000
Potassium as K	**31**	**mg/l**	A	200	400	800	
Magnesium as Mg	**121**	**mg/l**	C	70	100	200	500
Calcium as Ca	**230**	**mg/l**	C	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**<0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.5**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**3.7**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

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Group C: low risk water
Group D: high risk or water unsuitable for human consumption

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Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Windhoek
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Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

Approved Technical Signatory
Ms S. Rügheimer

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Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave

PO Box 86782, Windhoek, Namibi

TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH1-4
Date of sampling	8 Dec 2021, 15h01
Test item number	I212234/9

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.1**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**531**	**mS/m**	D	150	300	400	
Turbidity	**0.29**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**3181**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**550**	**mg/l**					
Total Hardness as $CaCO_3$	**1055**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**569**	**mg/l**	C	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**486**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**991**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**2.0**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**528**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**40**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.02**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**776**	**mg/l**	C	100	400	800	2000
Potassium as K	**30**	**mg/l**	A	200	400	800	
Magnesium as Mg	**118**	**mg/l**	C	70	100	200	500
Calcium as Ca	**228**	**mg/l**	C	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.5**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.8**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**3.5**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
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Unit 16, Ben Amathila Ave
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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
3.5-4.0 mg/l fluoride: severe tooth damage especially in infants' temporary and permanent teeth; softening of the enamel and dentine will occur on continuous use of water. Threshold for chronic effects of fluoride exposure.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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Windhoek
info@analab.com.n
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Cell +264 81 611 884
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walvisbaylab@analab.com.n
Cell +264 81 122 158
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PO Box 86782, Windhoek, Namibi

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TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH1-6
Date of sampling	9 Dec 2021, 13h55
Test item number	I212234/10

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.1**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**536**	**mS/m**	D	150	300	400	
Turbidity	**0.62**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**3190**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**550**	**mg/l**					
Total Hardness as $CaCO_3$	**997**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**494**	**mg/l**	B	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**502**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1037**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**1.9**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**534**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**33**	**mg/l**	C	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**0.02**	**mg/l**					
Sodium as Na	**791**	**mg/l**	C	100	400	800	2000
Potassium as K	**31**	**mg/l**	A	200	400	800	
Magnesium as Mg	**122**	**mg/l**	C	70	100	200	500
Calcium as Ca	**198**	**mg/l**	B	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.5**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.0**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**3.7**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Windhoek
info@analab.com.n
Tel +264 61 210 13
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71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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71 Newcastle Stree

Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave

PO Box 86782, Windhoek, Namibi

TEST REPORT

To:	**Digby Wells Environmental SA**		
	48 Grosvenor Road	Date received:	15/Dec/21
	Bryanston	Date analysed:	14 Jan - 8 Feb 2022
	2191	Date reported:	10/Feb/22
	South Africa		
Attn:	Megan Edwards	Client Reference no.:	AFT 7220
email:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	27117899495	Lab Reference:	I212234
		Enquiries: Ms Manuela Mayer	

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH10-1
Date of sampling	13 Dec 2021, 11h00
Test item number	I212234/11

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**658**	**mS/m**	D	150	300	400	
Turbidity	**0.50**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4100**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**410**	**mg/l**					
Total Hardness as $CaCO_3$	**1666**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**941**	**mg/l**	C	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**725**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1383**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.5**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**948**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**23**	**mg/l**	C	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**832**	**mg/l**	D	100	400	800	2000
Potassium as K	**34**	**mg/l**	A	200	400	800	
Magnesium as Mg	**176**	**mg/l**	C	70	100	200	500
Calcium as Ca	**377**	**mg/l**	C	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**<0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.4**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.2**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

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Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Windhoek
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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
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Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
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Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH10-2
Date of sampling	13 Dec 2021, 19h00
Test item number	I212234/12

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**664**	**mS/m**	D	150	300	400	
Turbidity	**0.70**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4164**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**420**	**mg/l**					
Total Hardness as $CaCO_3$	**1655**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**939**	**mg/l**	C	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**717**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1360**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.6**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**981**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**27**	**mg/l**	C	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**866**	**mg/l**	D	100	400	800	2000
Potassium as K	**33**	**mg/l**	A	200	400	800	
Magnesium as Mg	**174**	**mg/l**	C	70	100	200	500
Calcium as Ca	**376**	**mg/l**	C	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.4**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.8**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms S. Rügheimer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave

PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH10-3
Date of sampling	14 Dec 2021, 05h00
Test item number	I212234/13

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.1**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**668**	**mS/m**	D	150	300	400	
Turbidity	**0.75**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4164**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**420**	**mg/l**					
Total Hardness as $CaCO_3$	**1634**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**901**	**mg/l**	C	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**733**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1383**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.6**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**964**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**26**	**mg/l**	C	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**874**	**mg/l**	D	100	400	800	2000
Potassium as K	**34**	**mg/l**	A	200	400	800	
Magnesium as Mg	**178**	**mg/l**	C	70	100	200	500
Calcium as Ca	**361**	**mg/l**	C	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.4**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
info@analab.com.n
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Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
Bryanston
2191
South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH10-4
Date of sampling	14 Dec 2021, 20h00
Test item number	I212234/14

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**670**	**mS/m**	D	150	300	400	
Turbidity	**0.40**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4241**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**435**	**mg/l**					
Total Hardness as $CaCO_3$	**1631**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**919**	**mg/l**	C	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**712**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1406**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.6**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1002**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**23**	**mg/l**	C	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**894**	**mg/l**	D	100	400	800	2000
Potassium as K	**34**	**mg/l**	A	200	400	800	
Magnesium as Mg	**173**	**mg/l**	C	70	100	200	500
Calcium as Ca	**368**	**mg/l**	C	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.4**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.8**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
info@analab.com.n
Tel +264 61 210 13
Cell +264 81 611 884
71 Newcastle Stree
Walvis Bay
walvisbaylab@analab.com.n
Cell +264 81 122 158
Unit 16, Ben Amathila Ave
PO Box 86782, Windhoek, Namibi

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
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Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
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TEST REPORT

To: **Digby Wells Environmental SA**
48 Grosvenor Road
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South Africa
Attn: Megan Edwards
email: megan.edwards@digbywells.com
Tel: 27117899495

Date received: 15/Dec/21
Date analysed: 14 Jan - 8 Feb 2022
Date reported: 10/Feb/22

Client Reference no.: AFT 7220
Quotation no.: QU-6835
Lab Reference: I212234
Enquiries: Ms Manuela Mayer

Sample details	Borehole samples
Location of sampling point	Uis, Afritin Mine
Description of sampling point	BH10-5
Date of sampling	15 Dec 2021, 12h00
Test item number	I212234/15

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**670**	**mS/m**	D	150	300	400	
Turbidity	**0.40**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4386**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**425**	**mg/l**					
Total Hardness as $CaCO_3$	**1642**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**921**	**mg/l**	C	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**721**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1429**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.6**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1002**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**52**	**mg/l**	D	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonia as N	**<0.02**	**mg/l**					
Sodium as Na	**892**	**mg/l**	D	100	400	800	2000
Potassium as K	**34**	**mg/l**	A	200	400	800	
Magnesium as Mg	**175**	**mg/l**	C	70	100	200	500
Calcium as Ca	**369**	**mg/l**	C	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.4**						
Langelier Index	**0.5**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.9**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**7.2**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek
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Remark: Overall classification of water, considering only constituents that have been tested for:
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Sample acceptance: Sample was collected in clients' own bottle / in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

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Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

Approved Technical Signatory
Ms S. Rügheimer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street
Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH11-1
Date of sampling	2022/01/16; 15:00
Test item number	I220280/1

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**2190**	**mS/m**	D	150	300	400	
Turbidity	**0.35**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**14809**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**230**	**mg/l**					
Total Hardness as $CaCO_3$	**5093**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**2812**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**2281**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**5991**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**3131**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**70**	**mg/l**	D	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**3448**	**mg/l**	D	100	400	800	2000
Potassium as K	**110**	**mg/l**	A	200	400	800	
Magnesium as Mg	**554**	**mg/l**	D	70	100	200	500
Calcium as Ca	**1126**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.1**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.18**	**mg/l**	B	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.2**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.5**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**51.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Walvis Bay:
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PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH11-2
Date of sampling	2022/01/17; 14:40
Test item number	I220280/2

				Recommended maximum limits			
				Human consumption			**Livestock**
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**2010**	**mS/m**	D	150	300	400	
Turbidity	**0.30**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**13410**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**235**	**mg/l**					
Total Hardness as $CaCO_3$	**5000**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**2797**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**2203**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**5530**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.2**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**2785**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**70**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**2891**	**mg/l**	D	100	400	800	2000
Potassium as K	**95**	**mg/l**	A	200	400	800	
Magnesium as Mg	**535**	**mg/l**	D	70	100	200	500
Calcium as Ca	**1120**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.1**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.19**	**mg/l**	B	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.2**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.5**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**45.6**	increasing corrosive tendency		Applies to water in the pH range 7-8			
				which also contains dissolved oxygen			
				ratios <0.2 no corrosive properties			
				ratios >0.2 increasing corrosive tendency			

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info@analab.com.na
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71 Newcastle Street
Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH11-3
Date of sampling	2022/01/17; 14:20
Test item number	I220280/3

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1961**	**mS/m**	D	150	300	400	
Turbidity	**0.25**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**12764**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**235**	**mg/l**					
Total Hardness as $CaCO_3$	**5033**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**2797**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**2236**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**5185**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.2**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**2656**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**53**	**mg/l**	D	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**2787**	**mg/l**	D	100	400	800	2000
Potassium as K	**94**	**mg/l**	A	200	400	800	
Magnesium as Mg	**543**	**mg/l**	D	70	100	200	500
Calcium as Ca	**1120**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.1**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.49**	**mg/l**	B	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.2**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.5**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**42.9**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
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Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

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Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH11-4
Date of sampling	2022/01/18; 15:40
Test item number	I220280/4

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1938**	**mS/m**	D	150	300	400	
Turbidity	**0.20**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**12799**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**240**	**mg/l**					
Total Hardness as $CaCO_3$	**4917**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**2714**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**2203**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**5300**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.2**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**2670**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**56**	**mg/l**	D	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**2723**	**mg/l**	D	100	400	800	2000
Potassium as K	**91**	**mg/l**	A	200	400	800	
Magnesium as Mg	**535**	**mg/l**	D	70	100	200	500
Calcium as Ca	**1087**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**0.24**	**mg/l**	B	0.05	1.0	2.0	10
Iron as Fe	**0.97**	**mg/l**	B	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.2**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.5**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**42.8**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms. Manuela Mayer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street
Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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PO Box 86782, Windhoek, Namibia

Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH11-5
Date of sampling	2022/01/18; 15:00
Test item number	I220280/5

				Recommended maximum limits			
				Human consumption			**Livestock**
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1910**	**mS/m**	D	150	300	400	
Turbidity	**0.20**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**12371**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**235**	**mg/l**					
Total Hardness as $CaCO_3$	**4986**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**2779**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**2207**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**4954**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.2**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**2656**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**54**	**mg/l**	D	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**2639**	**mg/l**	D	100	400	800	2000
Potassium as K	**90**	**mg/l**	A	200	400	800	
Magnesium as Mg	**536**	**mg/l**	D	70	100	200	500
Calcium as Ca	**1113**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.1**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.16**	**mg/l**	B	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.2**						
Langelier Index	**0.8**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.4**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**41.5**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH4-1
Date of sampling	2022/01/11; 17:00
Test item number	I220280/6

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**793**	**mS/m**	D	150	300	400	
Turbidity	**0.20**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4654**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**400**	**mg/l**					
Total Hardness as $CaCO_3$	**2178**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1099**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1079**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1659**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.9**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**959**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**12**	**mg/l**	B	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**994**	**mg/l**	D	100	400	800	2000
Potassium as K	**46**	**mg/l**	A	200	400	800	
Magnesium as Mg	**262**	**mg/l**	D	70	100	200	500
Calcium as Ca	**440**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.05**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**8.4**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Windhoek:
info@analab.com.na
Tel +264 61 210 132
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71 Newcastle Street

Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
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PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH4-2
Date of sampling	2022/01/12; 17:00
Test item number	I220280/7

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**798**	**mS/m**	D	150	300	400	
Turbidity	**0.25**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4719**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**380**	**mg/l**					
Total Hardness as $CaCO_3$	**2274**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1154**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1120**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1728**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.8**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**953**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**6.0**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1002**	**mg/l**	D	100	400	800	2000
Potassium as K	**47**	**mg/l**	A	200	400	800	
Magnesium as Mg	**272**	**mg/l**	D	70	100	200	500
Calcium as Ca	**462**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.8**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**9.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

Approved Technical Signatory
Ms. Manuela Mayer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street

Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

TEST REPORT

To:	**Digby Wells Environmental SA (Pty) Ltd.**		
	48 Grosvenor Road	Date received:	26/Jan/22
	Brtanston 2191	Date analysed:	8 February - 28 March 2022
	South Africa	Date reported:	29/Mar/22
Attn:	Ms Megan Edwards	Client Reference no.:	AFT-7220
e-mail:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	+27 11 789 9495	Lab Reference:	I220280
		Enquiries:	Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH4-3
Date of sampling	2022/01/13; 17:00
Test item number	I220280/8

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**798**	**mS/m**	D	150	300	400	
Turbidity	**0.25**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4843**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**385**	**mg/l**					
Total Hardness as $CaCO_3$	**2248**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1136**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1112**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1866**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.8**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**948**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**11**	**mg/l**	B	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**976**	**mg/l**	D	100	400	800	2000
Potassium as K	**47**	**mg/l**	A	200	400	800	
Magnesium as Mg	**270**	**mg/l**	D	70	100	200	500
Calcium as Ca	**455**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**9.4**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH4-4
Date of sampling	2022/010/13; 17:10
Test item number	I220280/9

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**803**	**mS/m**	D	150	300	400	
Turbidity	**0.75**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4917**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**385**	**mg/l**					
Total Hardness as $CaCO_3$	**2265**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1141**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1124**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1889**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.8**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**986**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**8.8**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**993**	**mg/l**	D	100	400	800	2000
Potassium as K	**48**	**mg/l**	A	200	400	800	
Magnesium as Mg	**273**	**mg/l**	D	70	100	200	500
Calcium as Ca	**457**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**9.6**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
6-10 mg/l nitrate as N: rare instances of methhaemoglobinaemia in infants; no effects in adults. Concentrations in this range generally well tolerated.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
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Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH4-5
Date of sampling	2022/01/13; 17:00
Test item number	I220280/10

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**805**	**mS/m**	D	150	300	400	
Turbidity	**0.30**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5074**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**380**	**mg/l**					
Total Hardness as $CaCO_3$	**2307**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1154**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1153**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1774**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.9**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1215**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**8.1**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1030**	**mg/l**	D	100	400	800	2000
Potassium as K	**48**	**mg/l**	A	200	400	800	
Magnesium as Mg	**280**	**mg/l**	D	70	100	200	500
Calcium as Ca	**462**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.03**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**9.9**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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TEST REPORT

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48 Grosvenor Road
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South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH9-1
Date of sampling	2022/01/07; 20:00
Test item number	I220280/11

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.3**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**433**	**mS/m**	D	150	300	400	
Turbidity	**0.70**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**2490**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**395**	**mg/l**					
Total Hardness as $CaCO_3$	**760**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**390**	**mg/l**	B	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**371**	**mg/l**	B	290	420	840	2057
Chloride as Cl^-	**737**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**2.0**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**509**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**12**	**mg/l**	B	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**677**	**mg/l**	C	100	400	800	2000
Potassium as K	**29**	**mg/l**	A	200	400	800	
Magnesium as Mg	**90**	**mg/l**	B	70	100	200	500
Calcium as Ca	**156**	**mg/l**	B	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.04**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.8**						
Langelier Index	**0.5**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.2**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**4.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms. Manuela Mayer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street
Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
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Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH9-2
Date of sampling	2022/01/07; 20:00
Test item number	I220280/12

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.3**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**428**	**mS/m**	D	150	300	400	
Turbidity	**0.25**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**2556**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**395**	**mg/l**					
Total Hardness as $CaCO_3$	**775**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**405**	**mg/l**	B	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**371**	**mg/l**	B	290	420	840	2057
Chloride as Cl^-	**830**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**2.1**	**mg/l**	C	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**504**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**12**	**mg/l**	B	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**650**	**mg/l**	C	100	400	800	2000
Potassium as K	**28**	**mg/l**	A	200	400	800	
Magnesium as Mg	**90**	**mg/l**	B	70	100	200	500
Calcium as Ca	**162**	**mg/l**	B	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.7**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.2**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**4.3**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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This test report is only valid without any alterations and shall not be published or reproduced except in full, with written consent of the laboratory.

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Naturally occurring chemicals that are of health significance in drinking water
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Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH9-3
Date of sampling	2022/01/08; 20:00
Test item number	I220280/13

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.7**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**437**	**mS/m**	D	150	300	400	
Turbidity	**0.25**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**2583**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**365**	**mg/l**					
Total Hardness as $CaCO_3$	**748**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**365**	**mg/l**	A	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**383**	**mg/l**	B	290	420	840	2057
Chloride as Cl^-	**853**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**2.0**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**523**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**12**	**mg/l**	B	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**665**	**mg/l**	C	100	400	800	2000
Potassium as K	**29**	**mg/l**	A	200	400	800	
Magnesium as Mg	**93**	**mg/l**	B	70	100	200	500
Calcium as Ca	**146**	**mg/l**	A	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.8**						
Langelier Index	**0.9**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.9**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**4.8**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
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Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
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Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH9-4
Date of sampling	2022/01/09; 20:00
Test item number	I220280/14

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.2**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**453**	**mS/m**	D	150	300	400	
Turbidity	**0.30**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**2605**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**395**	**mg/l**					
Total Hardness as $CaCO_3$	**856**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**444**	**mg/l**	B	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**412**	**mg/l**	B	290	420	840	2057
Chloride as Cl^-	**853**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**2.1**	**mg/l**	C	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**485**	**mg/l**	B	200	600	1200	1000
Nitrate as N	**13**	**mg/l**	B	10	20	40	100
Nitrite as N	**0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**662**	**mg/l**	C	100	400	800	2000
Potassium as K	**30**	**mg/l**	A	200	400	800	
Magnesium as Mg	**100**	**mg/l**	B	70	100	200	500
Calcium as Ca	**178**	**mg/l**	B	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.7**						
Langelier Index	**0.5**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.2**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**4.3**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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pH: Optimum pH 6.5-8.
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Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
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Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

Approved Technical Signatory
Ms. Manuela Mayer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street
Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH9-5
Date of sampling	2022/01/09; 21:00
Test item number	I220280/15

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.2**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**474**	**mS/m**	D	150	300	400	
Turbidity	**0.35**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**2864**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**385**	**mg/l**					
Total Hardness as $CaCO_3$	**908**	**mg/l**	C	300	650	1300	
Ca-Hardness as $CaCO_3$	**472**	**mg/l**	B	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**437**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**876**	**mg/l**	C	250	600	1200	1500-3000
Fluoride as F^-	**2.0**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**678**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**14**	**mg/l**	B	10	20	40	100
Nitrite as N	**0.02**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**689**	**mg/l**	C	100	400	800	2000
Potassium as K	**31**	**mg/l**	A	200	400	800	
Magnesium as Mg	**106**	**mg/l**	C	70	100	200	500
Calcium as Ca	**189**	**mg/l**	B	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.7**						
Langelier Index	**0.5**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.2**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**5.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH3-1
Date of sampling	2022/01/06; 19:50
Test item number	I220280/16

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**899**	**mS/m**	D	150	300	400	
Turbidity	**0.35**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5505**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**410**	**mg/l**					
Total Hardness as $CaCO_3$	**2344**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1146**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1198**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2166**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.0**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1101**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**5.8**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1160**	**mg/l**	D	100	400	800	2000
Potassium as K	**55**	**mg/l**	A	200	400	800	
Magnesium as Mg	**291**	**mg/l**	D	70	100	200	500
Calcium as Ca	**459**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**10.3**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH3-2
Date of sampling	2022/01/7; 18:00
Test item number	I220280/17

				Recommended maximum limits			
				Human consumption			**Livestock**
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**888**	**mS/m**	D	150	300	400	
Turbidity	**0.30**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5416**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**400**	**mg/l**					
Total Hardness as $CaCO_3$	**2377**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1166**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1211**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2120**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.9**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1057**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**5.6**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1159**	**mg/l**	D	100	400	800	2000
Potassium as K	**53**	**mg/l**	A	200	400	800	
Magnesium as Mg	**294**	**mg/l**	D	70	100	200	500
Calcium as Ca	**467**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**10.2**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
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South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH3-3
Date of sampling	2022/01/09; 18:00
Test item number	I220280/18

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**884**	**mS/m**	D	150	300	400	
Turbidity	**0.30**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5434**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**400**	**mg/l**					
Total Hardness as $CaCO_3$	**2372**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1161**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1211**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2143**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.9**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1062**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**5.8**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1149**	**mg/l**	D	100	400	800	2000
Potassium as K	**54**	**mg/l**	A	200	400	800	
Magnesium as Mg	**294**	**mg/l**	D	70	100	200	500
Calcium as Ca	**465**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.03**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**10.3**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Ms. Manuela Mayer

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PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
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Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

Approved Technical Signatory
Ms. Manuela Mayer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street

Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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PO Box 86782, Windhoek, Namibia

TEST REPORT

To:	**Digby Wells Environmental SA (Pty) Ltd.**		
	48 Grosvenor Road	Date received:	26/Jan/22
	Brtanston 2191	Date analysed:	8 February - 28 March 2022
	South Africa	Date reported:	29/Mar/22
Attn:	Ms Megan Edwards	Client Reference no.:	AFT-7220
e-mail:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	+27 11 789 9495	Lab Reference:	I220280
		Enquiries:	Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH3-4
Date of sampling	2022/01/10; 18:00
Test item number	I220280/19

				Recommended maximum limits			
				Human consumption			**Livestock**
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**881**	**mS/m**	D	150	300	400	
Turbidity	**0.55**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5447**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**400**	**mg/l**					
Total Hardness as $CaCO_3$	**2367**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1156**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1211**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2166**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.9**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1052**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**5.4**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1154**	**mg/l**	D	100	400	800	2000
Potassium as K	**53**	**mg/l**	A	200	400	800	
Magnesium as Mg	**294**	**mg/l**	D	70	100	200	500
Calcium as Ca	**463**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.03**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**10.4**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
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Group B: good quality water
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
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Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
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Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH3-5
Date of sampling	2022/01/10; 12:00
Test item number	I220280/20

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**883**	**mS/m**	D	150	300	400	
Turbidity	**0.40**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5408**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**395**	**mg/l**					
Total Hardness as $CaCO_3$	**2361**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1146**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1215**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2143**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**0.9**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1046**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**5.6**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1147**	**mg/l**	D	100	400	800	2000
Potassium as K	**55**	**mg/l**	A	200	400	800	
Magnesium as Mg	**295**	**mg/l**	D	70	100	200	500
Calcium as Ca	**459**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**10.4**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
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0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH12-1
Date of sampling	2022/01/11; 9:00
Test item number	I220280/21

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.1**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**838**	**mS/m**	D	150	300	400	
Turbidity	**0.25**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5262**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**385**	**mg/l**					
Total Hardness as $CaCO_3$	**2124**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1181**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**943**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1843**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.4**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1035**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**62**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.07**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1121**	**mg/l**	D	100	400	800	2000
Potassium as K	**52**	**mg/l**	A	200	400	800	
Magnesium as Mg	**229**	**mg/l**	D	70	100	200	500
Calcium as Ca	**473**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.8**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.5**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**9.6**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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TEST REPORT

To:	**Digby Wells Environmental SA (Pty) Ltd.**		
	48 Grosvenor Road	Date received:	26/Jan/22
	Brtanston 2191	Date analysed:	8 February - 28 March 2022
	South Africa	Date reported:	29/Mar/22
Attn:	Ms Megan Edwards	Client Reference no.:	AFT-7220
e-mail:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	+27 11 789 9495	Lab Reference:	I220280
		Enquiries: Ms Manuela Mayer	

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH12-2
Date of sampling	2022/01/11; 21:40
Test item number	I220280/22

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.1**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**812**	**mS/m**	D	150	300	400	
Turbidity	**0.30**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5022**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**285**	**mg/l**					
Total Hardness as $CaCO_3$	**2013**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1124**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**889**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1751**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.4**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1052**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**59**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.04**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1069**	**mg/l**	D	100	400	800	2000
Potassium as K	**51**	**mg/l**	A	200	400	800	
Magnesium as Mg	**216**	**mg/l**	D	70	100	200	500
Calcium as Ca	**450**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.03**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.5**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.8**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**12.5**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms. Manuela Mayer

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OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
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71 Newcastle Street
Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
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Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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PO Box 86782, Windhoek, Namibia

TEST REPORT

To:	**Digby Wells Environmental SA (Pty) Ltd.**		
	48 Grosvenor Road	Date received:	26/Jan/22
	Brtanston 2191	Date analysed:	8 February - 28 March 2022
	South Africa	Date reported:	29/Mar/22
Attn:	Ms Megan Edwards	Client Reference no.:	AFT-7220
e-mail:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	+27 11 789 9495	Lab Reference:	I220280
		Enquiries: Ms Manuela Mayer	

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH12-3
Date of sampling	2022/01/12; 9:20
Test item number	I220280/23

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.2**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**802**	**mS/m**	D	150	300	400	
Turbidity	**0.30**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5075**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**345**	**mg/l**					
Total Hardness as $CaCO_3$	**2012**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1126**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**885**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1751**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.4**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1062**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**58**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.05**	**mg/l**					10
Ammonium as N	**0.49**	**mg/l**					
Sodium as Na	**1081**	**mg/l**	D	100	400	800	2000
Potassium as K	**51**	**mg/l**	A	200	400	800	
Magnesium as Mg	**215**	**mg/l**	D	70	100	200	500
Calcium as Ca	**451**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.4**						
Langelier Index	**0.8**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**10.4**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
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Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

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	Brtanston 2191	Date analysed:	8 February - 28 March 2022
	South Africa	Date reported:	29/Mar/22
Attn:	Ms Megan Edwards	Client Reference no.:	AFT-7220
e-mail:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	+27 11 789 9495	Lab Reference:	I220280
		Enquiries: Ms Manuela Mayer	

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH12-4
Date of sampling	2022/01/12; 21:00
Test item number	I220280/24

				Recommended maximum limits			
				Human consumption			**Livestock**
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.2**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**3260**	**mS/m**	D	150	300	400	
Turbidity	**3.0**	**NTU**	B	1	5	10	
Total Dissolved Solids (calc.)	**22768**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**190**	**mg/l**					
Total Hardness as $CaCO_3$	**6597**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**2462**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**4134**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**9332**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**2.1**	**mg/l**	C	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**5449**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**12**	**mg/l**	B	10	20	40	100
Nitrite as N	**0.13**	**mg/l**					10
Ammonium as N	**0.44**	**mg/l**					
Sodium as Na	**5596**	**mg/l**	D	100	400	800	2000
Potassium as K	**232**	**mg/l**	B	200	400	800	
Magnesium as Mg	**1004**	**mg/l**	D	70	100	200	500
Calcium as Ca	**986**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.1**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**<0.1**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.4**						
Langelier Index	**0.8**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.5**	scaling		<6.5=scaling, >7,5=corrosive, $\geq$6.5 and $\leq$7.5=stable			
Corrosivity ratio	**99.2**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH12-5
Date of sampling	2022/01/13; 9:00
Test item number	I220280/25

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.2**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**785**	**mS/m**	D	150	300	400	
Turbidity	**0.60**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**4826**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**345**	**mg/l**					
Total Hardness as $CaCO_3$	**1876**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1049**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**828**	**mg/l**	C	290	420	840	2057
Chloride as Cl^-	**1728**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.4**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1002**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**49**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.06**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1000**	**mg/l**	D	100	400	800	2000
Potassium as K	**50**	**mg/l**	A	200	400	800	
Magnesium as Mg	**201**	**mg/l**	D	70	100	200	500
Calcium as Ca	**420**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.4**						
Langelier Index	**0.8**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**10.1**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

Approved Technical Signatory
Ms. Manuela Mayer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street

Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH6-1
Date of sampling	2022/01/15; 13:00
Test item number	I220280/26

				Recommended maximum limits			
				Human consumption			**Livestock**
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1152**	**mS/m**	D	150	300	400	
Turbidity	**0.35**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**7211**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**410**	**mg/l**					
Total Hardness as $CaCO_3$	**2781**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1229**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1552**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2857**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.4**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1593**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**7.8**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1526**	**mg/l**	D	100	400	800	2000
Potassium as K	**84**	**mg/l**	A	200	400	800	
Magnesium as Mg	**377**	**mg/l**	D	70	100	200	500
Calcium as Ca	**492**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.02**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.04**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**13.9**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
6-10 mg/l nitrate as N: rare instances of methhaemoglobinaemia in infants; no effects in adults. Concentrations in this range generally well tolerated.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH6-2
Date of sampling	2022/01/16; 13:00
Test item number	I220280/27

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1141**	**mS/m**	D	150	300	400	
Turbidity	**0.20**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**7048**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**410**	**mg/l**					
Total Hardness as $CaCO_3$	**2731**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1211**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1520**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2834**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.4**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1517**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**11**	**mg/l**	B	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1466**	**mg/l**	D	100	400	800	2000
Potassium as K	**81**	**mg/l**	A	200	400	800	
Magnesium as Mg	**369**	**mg/l**	D	70	100	200	500
Calcium as Ca	**485**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.02**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.04**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**13.6**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To:	**Digby Wells Environmental SA (Pty) Ltd.**		
	48 Grosvenor Road	Date received:	26/Jan/22
	Brtanston 2191	Date analysed:	8 February - 28 March 2022
	South Africa	Date reported:	29/Mar/22
Attn:	Ms Megan Edwards	Client Reference no.:	AFT-7220
e-mail:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	+27 11 789 9495	Lab Reference:	I220280
		Enquiries: Ms Manuela Mayer	

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH6-3
Date of sampling	2022/01/16; 14:00
Test item number	I220280/28

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1178**	**mS/m**	D	150	300	400	
Turbidity	**0.60**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**7106**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**405**	**mg/l**					
Total Hardness as $CaCO_3$	**2813**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1224**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1590**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2857**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.4**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1552**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**6.3**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1465**	**mg/l**	D	100	400	800	2000
Potassium as K	**84**	**mg/l**	A	200	400	800	
Magnesium as Mg	**386**	**mg/l**	D	70	100	200	500
Calcium as Ca	**490**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.02**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.05**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.7**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**14.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms. Manuela Mayer

This test report is only valid without any alterations and shall not be published or reproduced except in full, with written consent of the laboratory.

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH6-4
Date of sampling	2022/01/21; 6:00
Test item number	I220280/29

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1167**	**mS/m**	D	150	300	400	
Turbidity	**0.35**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**7387**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**405**	**mg/l**					
Total Hardness as $CaCO_3$	**2868**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1291**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1577**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2949**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1688**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**4.6**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1503**	**mg/l**	D	100	400	800	2000
Potassium as K	**82**	**mg/l**	A	200	400	800	
Magnesium as Mg	**383**	**mg/l**	D	70	100	200	500
Calcium as Ca	**517**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.02**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.04**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.6**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**14.6**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms. Manuela Mayer

This test report is only valid without any alterations and shall not be published or reproduced except in full, with written consent of the laboratory.

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OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street
Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
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Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH6-5
Date of sampling	2022/01/21; 18:00
Test item number	I220280/30

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1147**	**mS/m**	D	150	300	400	
Turbidity	**0.20**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**7132**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**405**	**mg/l**					
Total Hardness as $CaCO_3$	**2788**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1231**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1557**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2857**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1579**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**4.0**	**mg/l**	A	10	20	40	100
Nitrite as N	**<0.01**	**mg/l**					10
Ammonium as N	**<0.02**	**mg/l**					
Sodium as Na	**1482**	**mg/l**	D	100	400	800	2000
Potassium as K	**81**	**mg/l**	A	200	400	800	
Magnesium as Mg	**378**	**mg/l**	D	70	100	200	500
Calcium as Ca	**493**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.02**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**<0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.3**						
Langelier Index	**0.6**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**14.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

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Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH8-1
Date of sampling	2022/01/22; 22:00
Test item number	I220280/31

				Recommended maximum limits			
				Human consumption			**Livestock**
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.3**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**1107**	**mS/m**	D	150	300	400	
Turbidity	**5.8**	**NTU**	C	1	5	10	
Total Dissolved Solids (calc.)	**6924**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**200**	**mg/l**					
Total Hardness as $CaCO_3$	**2667**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1531**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**1137**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2650**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.2**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1444**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**73**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.61**	**mg/l**					10
Ammonium as N	**1.1**	**mg/l**					
Sodium as Na	**1439**	**mg/l**	D	100	400	800	2000
Potassium as K	**56**	**mg/l**	A	200	400	800	
Magnesium as Mg	**276**	**mg/l**	D	70	100	200	500
Calcium as Ca	**613**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.02**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**1.8**	**mg/l**	C	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.5**						
Langelier Index	**0.8**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.7**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**26.2**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH8-2
Date of sampling	2022/01/23; 9:40
Test item number	I220280/32

				Recommended maximum limits			
				Human consumption			**Livestock**
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**921**	**mS/m**	D	150	300	400	
Turbidity	**0.15**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5790**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**195**	**mg/l**					
Total Hardness as $CaCO_3$	**2115**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1209**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**906**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**2097**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1210**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**101**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.86**	**mg/l**					10
Ammonium as N	**1.4**	**mg/l**					
Sodium as Na	**1163**	**mg/l**	D	100	400	800	2000
Potassium as K	**50**	**mg/l**	A	200	400	800	
Magnesium as Mg	**220**	**mg/l**	D	70	100	200	500
Calcium as Ca	**484**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.05**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.6**						
Langelier Index	**0.4**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.2**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**21.6**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

Approved Technical Signatory
Ms. Manuela Mayer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street

Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH8-3
Date of sampling	2022/01; 9:00
Test item number	I220280/33

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**6.9**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**885**	**mS/m**	D	150	300	400	
Turbidity	**0.20**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5537**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**185**	**mg/l**					
Total Hardness as $CaCO_3$	**2052**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1171**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**881**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1982**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1133**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**99**	**mg/l**	D	10	20	40	100
Nitrite as N	**0.91**	**mg/l**					10
Ammonium as N	**2.2**	**mg/l**					
Sodium as Na	**1139**	**mg/l**	D	100	400	800	2000
Potassium as K	**48**	**mg/l**	A	200	400	800	
Magnesium as Mg	**214**	**mg/l**	D	70	100	200	500
Calcium as Ca	**469**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.6**						
Langelier Index	**0.3**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.4**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**21.5**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
>20 mg/l nitrate as N: methemoglobinaemia occurs in infants. Occurrence of mucous membrane irritation in adults

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH8-4
Date of sampling	2022/01; 9:00
Test item number	I220280/34

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**884**	**mS/m**	D	150	300	400	
Turbidity	**0.20**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5143**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**185**	**mg/l**					
Total Hardness as $CaCO_3$	**2067**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1194**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**873**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1982**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1139**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**10**	**mg/l**	A	10	20	40	100
Nitrite as N	**1.0**	**mg/l**					10
Ammonium as N	**2.1**	**mg/l**					
Sodium as Na	**1127**	**mg/l**	D	100	400	800	2000
Potassium as K	**48**	**mg/l**	A	200	400	800	
Magnesium as Mg	**212**	**mg/l**	D	70	100	200	500
Calcium as Ca	**478**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**<0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.02**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.6**						
Langelier Index	**0.4**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.3**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**21.5**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

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71 Newcastle Street
Walvis Bay:
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Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
10-20 mg/l nitrate as N: methhaemoglobinaemia may occur in infants. No effects in adults.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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Windhoek:
info@analab.com.na
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Walvis Bay:
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PO Box 86782, Windhoek, Namibia

TEST REPORT

To: **Digby Wells Environmental SA (Pty) Ltd.**
48 Grosvenor Road
Brtanston 2191
South Africa

Date received: 26/Jan/22
Date analysed: 8 February - 28 March 2022
Date reported: 29/Mar/22

Attn: Ms Megan Edwards
e-mail: megan.edwards@digbywells.com
Tel: +27 11 789 9495

Client Reference no.: AFT-7220
Quotation no.: QU-6835
Lab Reference: I220280
Enquiries: Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	BH8-5
Date of sampling	2022/01; 9:00
Test item number	I220280/35

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.0**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**898**	**mS/m**	D	150	300	400	
Turbidity	**0.20**	**NTU**	A	1	5	10	
Total Dissolved Solids (calc.)	**5193**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**190**	**mg/l**					
Total Hardness as $CaCO_3$	**2094**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**1196**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**898**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**1982**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.3**	**mg/l**	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**1144**	**mg/l**	C	200	600	1200	1000
Nitrate as N	**9.8**	**mg/l**	A	10	20	40	100
Nitrite as N	**1.1**	**mg/l**					10
Ammonium as N	**2.2**	**mg/l**					
Sodium as Na	**1162**	**mg/l**	D	100	400	800	2000
Potassium as K	**49**	**mg/l**	A	200	400	800	
Magnesium as Mg	**218**	**mg/l**	D	70	100	200	500
Calcium as Ca	**479**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**0.01**	**mg/l**	A	0.05	1.0	2.0	10
Iron as Fe	**0.01**	**mg/l**	A	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.6**						
Langelier Index	**0.4**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**6.2**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**21.0**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms. Manuela Mayer

This test report is only valid without any alterations and shall not be published or reproduced except in full, with written consent of the laboratory.

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Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

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Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Ms. Manuela Mayer

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.0-1.5 mg/l fluoride: slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
6-10 mg/l nitrate as N: rare instances of methhaemoglobinaemia in infants; no effects in adults. Concentrations in this range generally well tolerated.

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
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Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
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Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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TEST REPORT

To:	**Digby Wells Environmental SA (Pty) Ltd.**		
	48 Grosvenor Road	Date received:	26/Jan/22
	Brtanston 2191	Date analysed:	8 February - 28 March 2022
	South Africa	Date reported:	29/Mar/22
Attn:	Ms Megan Edwards	Client Reference no.:	AFT-7220
e-mail:	megan.edwards@digbywells.com	Quotation no.:	QU-6835
Tel:	+27 11 789 9495	Lab Reference:	I220280
		Enquiries:	Ms Manuela Mayer

Sample details	borehole water
Location of sampling point	Uis, Afritin mine
Description of sampling point	K5-PIT
Date of sampling	2022/01; 12:00
Test item number	I220280/36

				Recommended maximum limits			
				Human consumption			Livestock
Parameter	**Value**	**Units**	**Classification**	**Group A**	**Group B**	**Group C**	**watering**
p H	**7.5**		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	**3270**	**mS/m**	D	150	300	400	
Turbidity	**4.8**	**NTU**	B	1	5	10	
Total Dissolved Solids (calc.)	**22763**	**mg/l**					6000
P-Alkalinity as $CaCO_3$	**0**	**mg/l**					
Total Alkalinity as $CaCO_3$	**133**	**mg/l**					
Total Hardness as $CaCO_3$	**6657**	**mg/l**	D	300	650	1300	
Ca-Hardness as $CaCO_3$	**2445**	**mg/l**	D	375	500	1000	2500
Mg-Hardness as $CaCO_3$	**4213**	**mg/l**	D	290	420	840	2057
Chloride as Cl^-	**9102**	**mg/l**	D	250	600	1200	1500-3000
Fluoride as F^-	**1.9**	**mg/l**	B	1.5	2.0	3.0	2.0-6.0
Sulphate as SO_4^{2-}	**5830**	**mg/l**	D	200	600	1200	1000
Nitrate as N	**1.4**	**mg/l**	A	10	20	40	100
Nitrite as N	**0.22**	**mg/l**					10
Ammonium as N	**1.2**	**mg/l**					
Sodium as Na	**5505**	**mg/l**	D	100	400	800	2000
Potassium as K	**236**	**mg/l**	B	200	400	800	
Magnesium as Mg	**1023**	**mg/l**	D	70	100	200	500
Calcium as Ca	**979**	**mg/l**	D	150	200	400	1000
Manganese as Mn	**0.21**	**mg/l**	B	0.05	1.0	2.0	10
Iron as Fe	**0.18**	**mg/l**	B	0.1	1.0	2.0	10
Stability pH, at 25°C	**6.5**						
Langelier Index	**1.0**	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	**5.5**	scaling		<6.5=scaling, >7,5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	**142.3**	increasing corrosive tendency		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

Approved Technical Signatory
Ms. Manuela Mayer

Analytical Laboratory Services
OUR QUALITY IS IN THE DETAIL

Windhoek:
info@analab.com.na
Tel +264 61 210 132
Cell +264 81 611 8843
71 Newcastle Street
Walvis Bay:
walvisbaylab@analab.com.na
Cell +264 81 122 1588
Unit 16, Ben Amathila Ave.

PO Box 86782, Windhoek, Namibia

Remark: Overall classification of water, considering only constituents that have been tested for:
Group D: high risk or water unsuitable for human consumption

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and
South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.
The highest group assigned to any of the constituents determines the classification of the water as a whole.
Group A: excellent quality water
Group B: good quality water
Group C: low risk water
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

Sample acceptance: Sample was collected in bottles provided by the laboratory.
Sample was suitable for testing

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Assessment of water quality for human consumption

Naturally occurring chemicals that are of health significance in drinking water
Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.
1.5-3.5 mg/l fluoride: the threshold for marked dental mottling with associated tooth damage due to softening of enamel is 1.5mg/L. Above this, mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.

Chemicals from agricultural activities that are of health significance in drinking water
Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.
Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.
Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.
pH: Optimum pH 6.5-8.
pH does not exert direct health effects, but may exert indirect health effects via metal solubility.
Sodium: The average taste threshold for sodium is about 200 mg/l.
Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.
Magnesium: The average taste threshold for magnesium is about 70 mg/l
Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.
Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.
Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.
Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).
The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.
Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration

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Summary of test methods - Water Quality

Determinant	Unit	DL	Technique	Method reference
Absorbed oxygen	mg/l O_2	1	titrimetric	SANS 5220:2005
Acidity	mg/l $CaCO_3$	20	titrimetric	AWWA 2310 B
Alkalinity	mg/l $CaCO_3$	20	titrimetric	AWWA 2320 B
Ammonium	mg/l N	0.02	colorimetric	AWWA 4500-NH_3 F / modified Berthelot
Bicarbonate & Carbonate	mg/l $CaCO_3$	1	by calculation	
Biological oxygen demand, 5-day	mg/l O_2	2	electrometric	AWWA 5210 B
Biological oxygen demand, carbonacious	mg/l O_2	2	electrometric	AWWA 5210 B
Bromide & Iodide	mg/l Br^-	0.01	iodometric	P. Höfer
Chloride	mg/l Cl^-	1	argentometric	AWWA 4500-Cl^- B
Chlorine, free and total	mg/l Cl_2	0.05	colorimetric	AWWA 4500-Cl G
Chlorophyll a	µg/L	0.01	spectrophotometric	ISO 10260:1992 E
Chemical oxygen demand	mg/l O_2	1	colorimetric	AWWA 5220 D
Colour	Pt	10	colorimetric	AWWA Pt-Co-2120 B
Cyanide	mg/l CN	0.02	colorimetric	AWWA 4500-CN E
Density	mg/l g/ml	-	gravimetric	METH W 016
Dissolved oxygen	mg/l O_2	0.1	electrometric	AWWA 4550-O G
Electrical conductivity	mS/m	0.1	electrometric	AWWA 2510 B
Fat, oil & grease	mg/l	1	extraction/gavimetric	AWWA 5520 B
Fixed and volatile solids, ignited at 550°C	mg/l	1	gravimetric	AWWA 2540 E
Fluoride	mg/l F^-	0.1	electrometric	AWWA 4500-F C
Hardness	mg/l $CaCO_3$	1	by calculation	AWWA 2340 B
Hexavalent chromium	mg/l Cr	0.02	colorimetric	AWWA 3500-Cr B
Hydrolysable phosphates	mg/l P	0.01	digestion, PO4	AWWA 4500-P B.2 + E
Kjeldahl nitrogen	mg/l N	0.5	by calculation	
Molybdosilicate	mg/l SiO_2	0.4	colorimetric	AWWA 4500-Si C
Nitrate	mg/l N	0.5	colorimetric	Spectroquant / AWWA 4500-NO_3 E
Nitrite	mg/l N	0.01	colorimetric	AWWA 4500-NO2 B
Oxidation reduction potential (Redox)	mV	-	electrometric	AWWA 2580 B
pH		-	electrometric	AWWA 4500-H^+ B
Phenols	mg/l Phenol	0.05	colorimetric	ASTM D1783-01, B
Reactive phosphorous	mg/l PO_4	0.03	colorimetric	AWWA 4500-P E
Settable solids	mg/l	1	gravimetric	AWWA 2540 F
Sulfide	mg/l S^{2-}	0.05	colorimetric	AWWA 4500-S^{2-} D
Sulfite	mg/l SO_3^{2-}	2	iodometric	AWWA 4500-SO_3^{2-} B
Sulphate	mg/l SO_4	1	nephelometric / colorimetric	AWWA 4500-SO4 E / F
Total dissolved solids	mg/l	1	gravimetric	AWWA 2540 C
Total nitrogen	mg/l N	0.5	digestion, NO3	EN ISO 11905-1:1997
Total phosphorous	mg/l P	0.01	digestion, PO4	AWWA 4500-P B.5 + E
Total solids	mg/l	1	gravimetric	AWWA 2540 B
Total suspended solids	mg/l	1	gravimetric	AWWA 2540 D
Turbidity	NTU	0.05	nephelometric	AWWA 2130 B
UV absorbing organic constituents at 254nm	cm^{-1}	-	colorimetric	AWWA 5910 B

Aluminium	mg/l Al	0.01		AWWA ICP-3500-Al C
Antimony	mg/l Sb	0.01		AWWA ICP-3500-Sb C
Arsenic	mg/l As	0.01		AWWA ICP-3500-As D
Barium	mg/l Ba	0.01		AWWA ICP-3500-Ba C
Beryllium	mg/l B	0.01		AWWA ICP-3500-Be
Bismuth	mg/l Bi	0.01		AWWA ICP-3500-Bi
Boron	mg/l B	0.01		AWWA ICP-3500-B D
Cadmium	mg/l Cd	0.01		AWWA ICP-3500-Cd C

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Calcium	mg/l Ca	0.1		AWWA ICP-3500-Ca C
Chromium (total)	mg/l Cr	0.01		AWWA ICP-3500-Cr C
Cobalt	mg/l Co	0.01		AWWA ICP-3500-Co C
Copper	mg/l Cu	0.01		AWWA ICP-3500-Cu C
Gold	mg/l Au	0.01		AWWA ICP-3500-Au
Iron	mg/l Fe	0.01		AWWA ICP-3500-Fe C
Lead	mg/l Pb	0.01		AWWA ICP-3500-Pb C
Lithium	mg/l Li	0.01		AWWA ICP-3500-Li C
Magnesium	mg/l Mg	0.1		AWWA ICP-3500-Mg C
Manganese	mg/l Mn	0.01		AWWA ICP-3500-Mn C
Mercury	mg/l Hg	0.01		AWWA ICP-3500-Hg
Molybdenum	mg/l Mo	0.01		AWWA ICP-3500-Mo C
Nickel	mg/l Ni	0.01		AWWA ICP-3500-Ni C
Potassium	mg/l K	0.1		AWWA ICP-3500-K C
Rubidium	mg/l Rb	0.01		ICP-OES
Selenium	mg/l Se	0.01		AWWA ICP-3500-Se I
Silica	mg/l Si	0.01		ICP-OES
Silver	mg/l Ag	0.01		AWWA ICP-3500-Ag
Sodium	mg/l Na	0.1		AWWA ICP-3500-Na C
Strontium	mg/l Sr	0.01		AWWA ICP-3500-Sr C
Thallium	mg/l Th	0.01		AWWA ICP-3500-Tl C
Tellurium	mg/l Te	0.01		AWWA ICP-3500-Te
Tin	mg/l Sn	0.01		AWWA ICP-3500-Sn
Titanium	mg/l Ti	0.01		AWWA ICP-3500-Ti
Uranium	mg/l U	0.01		AWWA ICP-3500-U
Vanadium	mg/l V	0.01		AWWA ICP-3500-V C
Zinc	mg/l Zn	0.01		AWWA ICP-3500-Zn C

Lower reporting limit

These are estimated values only; accurate lower levels of detection (LLDs) (measurement as part of a method) and method detection levels (MDLs) (measurement for the whole method) still have to be established
Given the varied matrices submitted to the laboratory and divers quality needs method and/or reagent blanks, performance evaluation samples and duplicate results may be included to assist in appropriate use of laboratory data.

All submitted samples are initially run undiluted unless sample dilutions are required in order to reduce or eliminate known matrix / interference effects. When an analyte concentration exceeds the calibration or linear range, the sample is re-analysed after appropriate dilution. The analyst will use the least dilution necessary to bring the analyte within the range. In both cases, a loss of sensitivity is experienced. All sample dilutions result in an increase in the lower reporting limit by a factor equal to the dilution. The less than symbol "<" is used for qualified data below the lower reporting limit.

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria

P.O. Box 283, Persequor Park, 0020
Tel: +2712 - 349 - 1066
Fax: +2786 - 654 - 2570
e-mail: admin@waterlab.co.za

T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2022-02-04 **Date completed:** 2022-02-11

Project number: 1000 **Report number:** 107136 **Order number:** AFT7220

Client name: Digby Wells Environmental **Contact person:** Ms. M Edwards

Address: Turnberry Office Park, 48 Grosvenor Rd, Bryanston, JHB 2191 **e-mail:** megan.edwards@digbywells.com

Telephone: 011 789 9498 **Facsimile:** 011 069 6801 **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification: Rain 2
Sample Number			152421
Date\Time Sampled			N/A
Chloride as Cl	A	WLAB046	9

A. van de Wetering - Chemical Technical Signatory

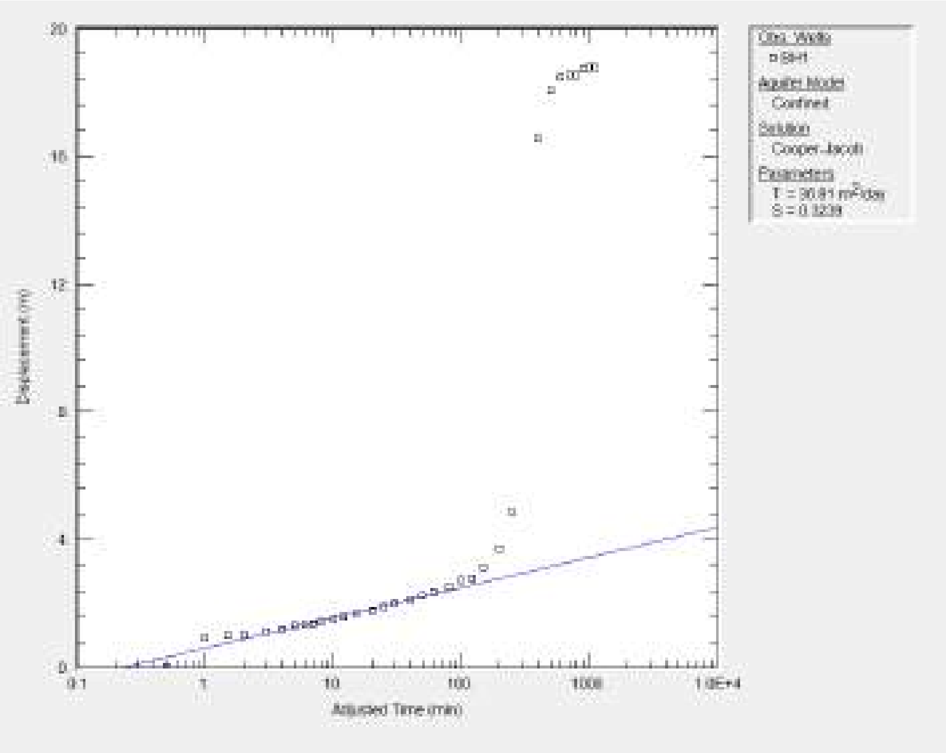
A = Accredited N = Not Accredited S = Subcontracted
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Scope of Accreditation for this Laboratory.
Results marked "Subcontracted Test" in this report are not included in the SANAS Scope of Accreditation for this Laboratory.

Sample condition acceptable unless specified on the report.

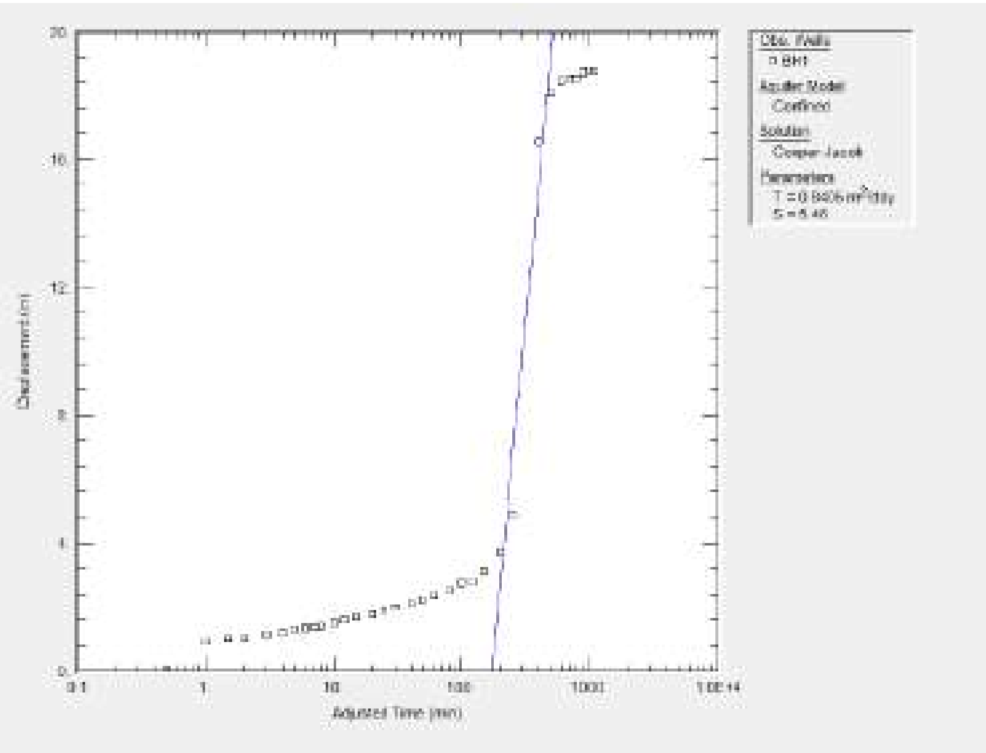
Appendix C: Aquifer Test Results

Observation Borehole Comments

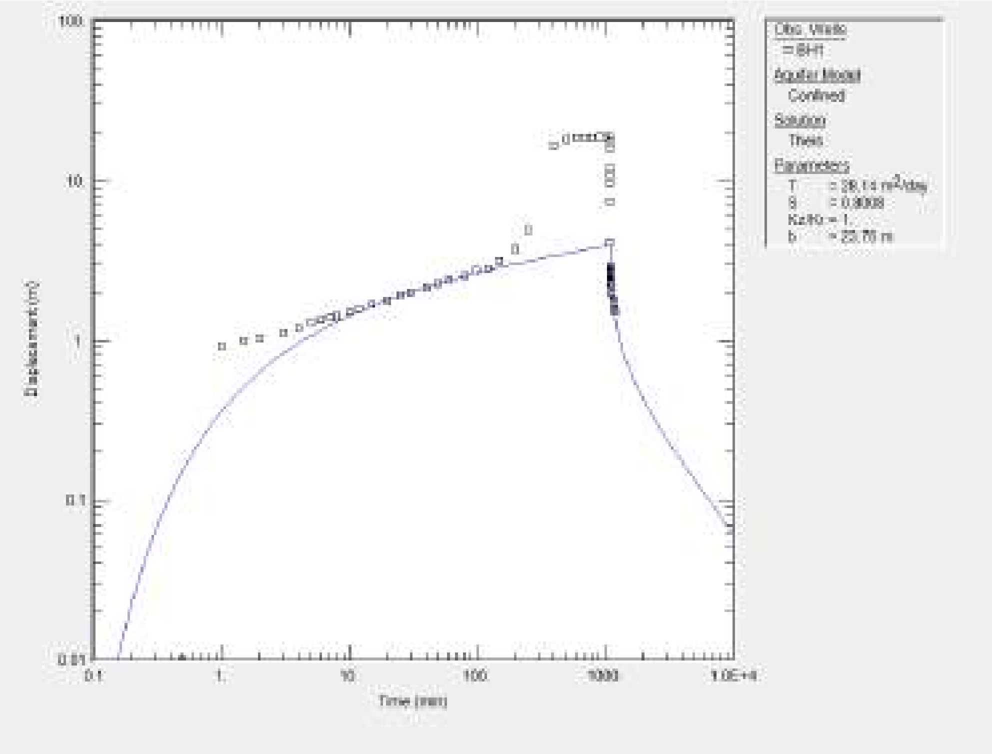
Aquifer Tested Borehole	Test	Observation Borehole	Comments
BH1	CDT1	BH2	Observation water levels decreased by 8 cm during the aquifer test
BH1	CDT1	BH10	Observation water levels were not affected during the CDT test
BH1	CDT2	BH2	Observation water levels decreased by 12 m during the aquifer test
BH1	CDT2	BH10	Observation water levels were not affected during the CDT test
BH2	CDT1	BH1	Observation water levels were not affected during the CDT test
BH2	CDT1	BH10	Observation water levels were not affected during the CDT test
BH3	CDT1	BH4	Observation water levels were not affected during the CDT test
BH3	CDT1	BH6	Observation water levels were not affected during the CDT test
BH3	CDT2	BH4	Observation water levels decreased by 20 cm during the aquifer test
BH3	CDT2	BH6	Observation water levels were not affected during the CDT test
BH4	CDT1	BH3	Observation water levels decreased by 21 cm during the aquifer test
BH4	CDT1	BH6	Observation water levels decreased by 3 cm during the aquifer test
BH6	CDT1	BH3	Observation water levels were not affected during the CDT test
BH6	CDT1	BH4	Observation water levels decreased by 7 cm during the aquifer test
BH6	CDT2	BH3	Observation water levels were not affected during the CDT test
BH6	CDT2	BH4	Observation water levels decreased by 5 cm during the aquifer test
BH6	CDT3	BH3	Observation water levels were not affected during the CDT test
BH6	CDT3	BH4	Observation water levels decreased by 61 cm during the aquifer test
BH8	CDT1	BH11	Observation water levels decreased by 21 cm during the aquifer test
BH9	CDT1	BH10	Observation water levels decreased by 30 cm during the aquifer test
BH9	CDT1	BH12	Observation water levels decreased by 3 cm during the aquifer test
BH10	CDT1	BH1	Observation water levels not measured
BH10	CDT1	BH2	Observation water levels not measured
BH10	CDT2	BH1	Observation water levels were not affected during the CDT test, water levels were recovering from abstraction pumping prior to the CDT test
BH10	CDT2	BH2	Observation water levels were not affected during the CDT test, water levels were recovering from abstraction pumping prior to the CDT test
BH11	CDT1	BH8	Observation water levels decreased by 18 cm during the aquifer test
BH12	CDT1	BH9	Observation water levels were not affected during the CDT, water levels were recovering from the CDT test



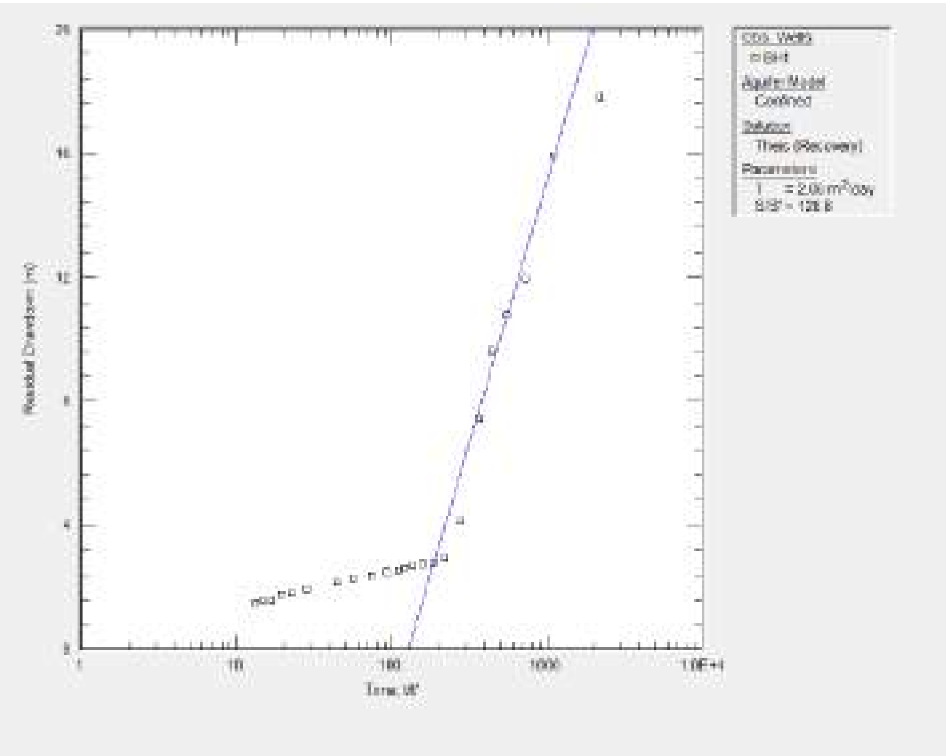
BH1 CDT1 Cooper-Jacob Early



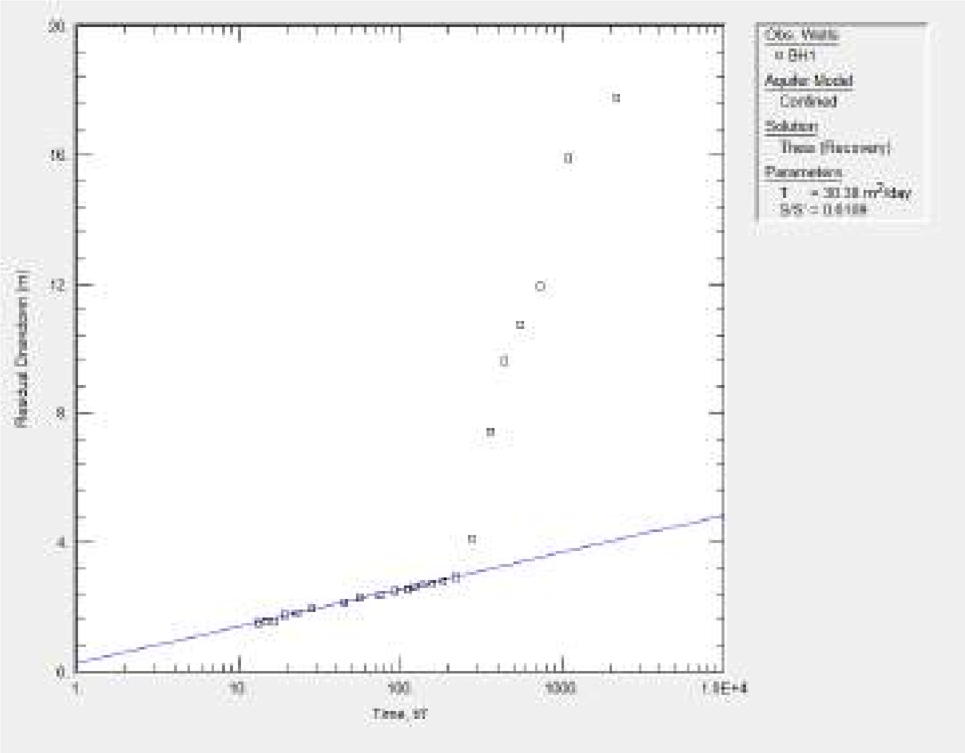
BH1 CDT1 Cooper-Jacob Late



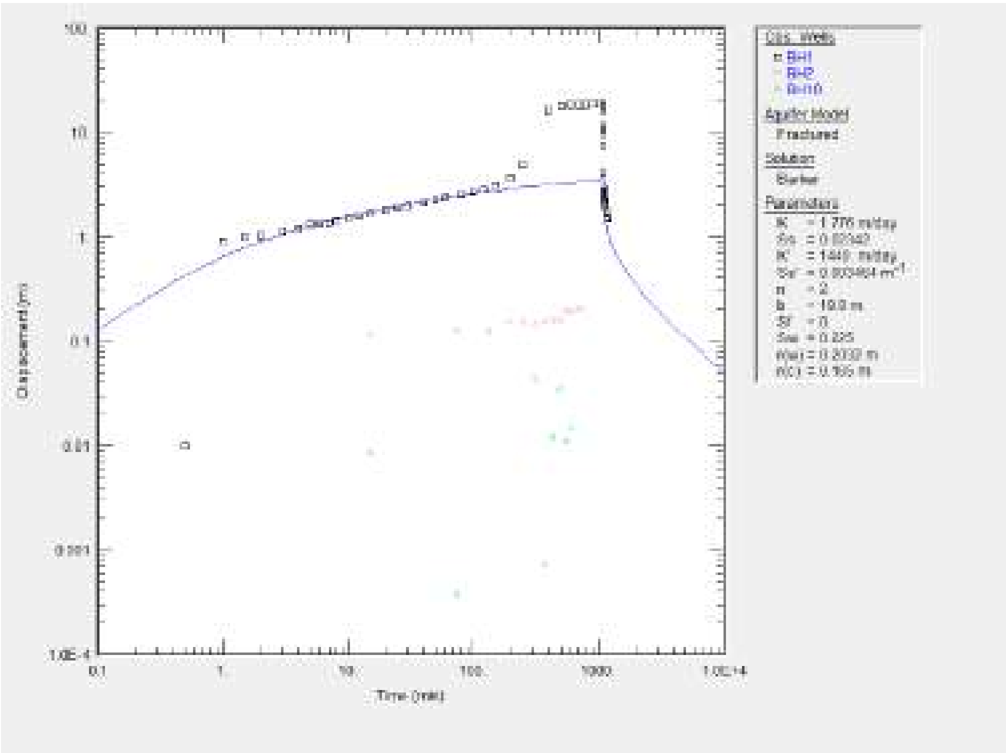
BH1 CDT1 Theis



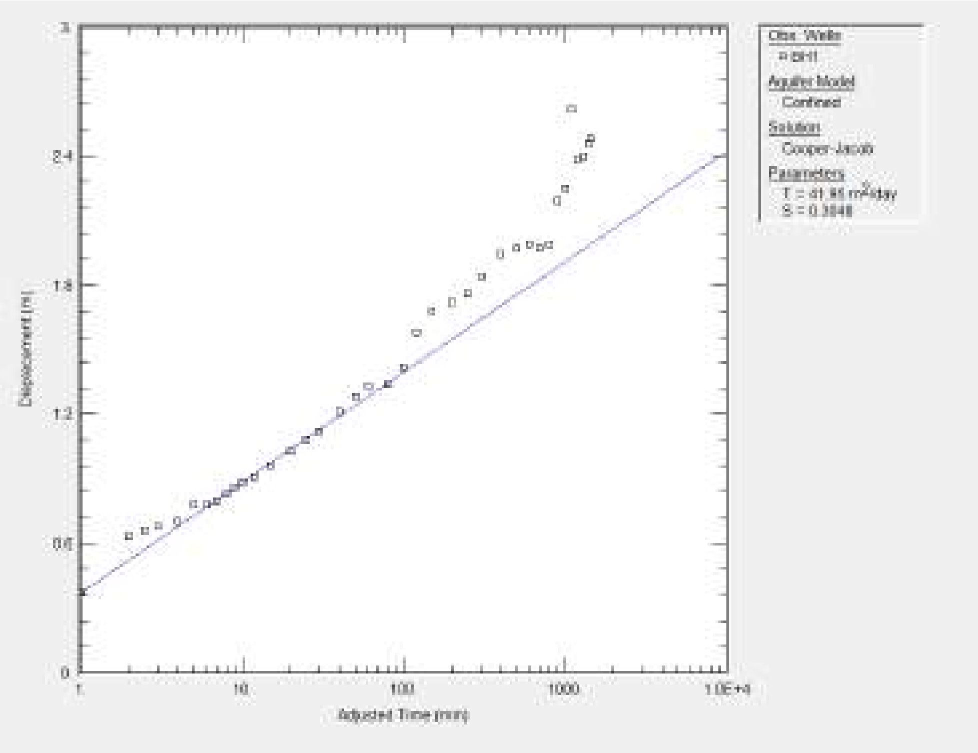
BH1 CDT1 Theis Recovery Early



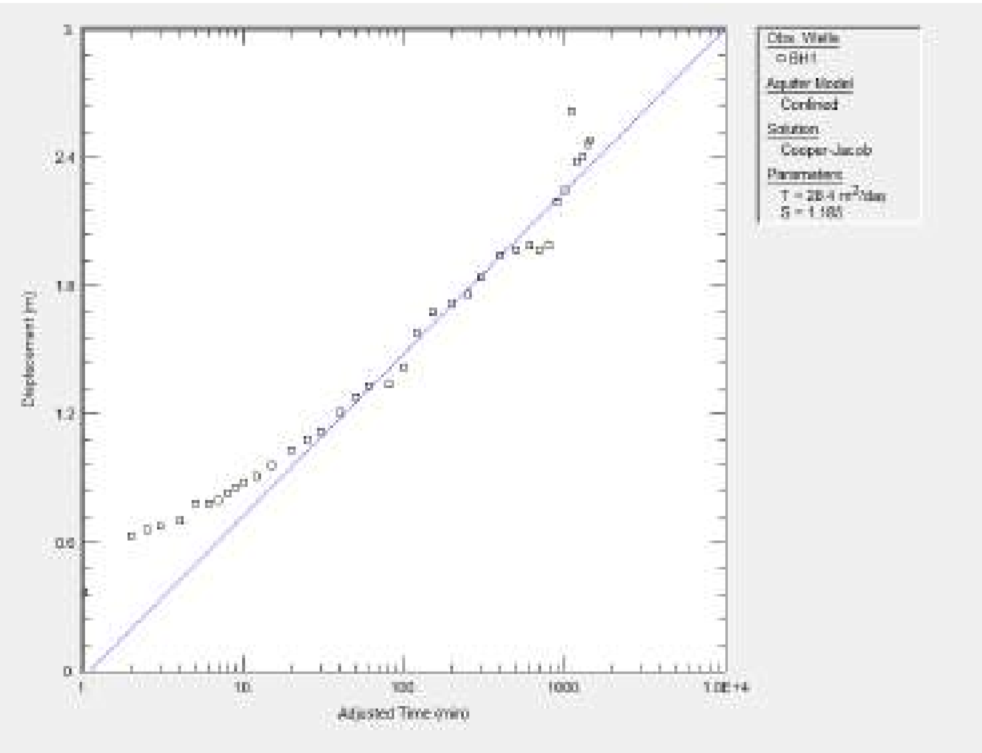
BH1 CDT1 Theis Recovery Late



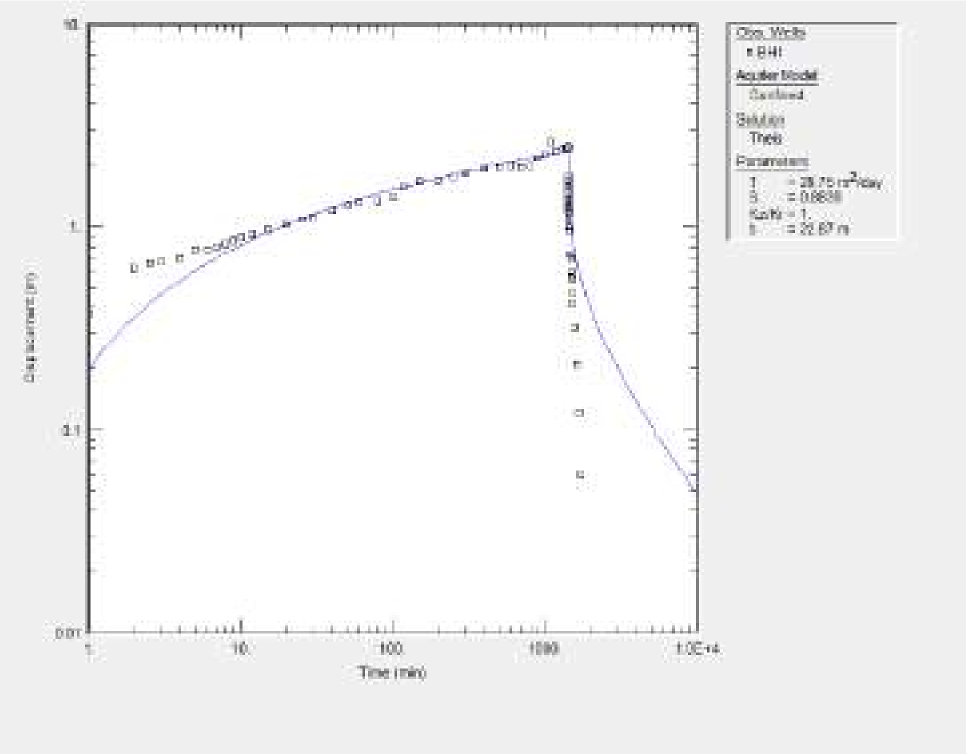
BH1 CDT1 Moench



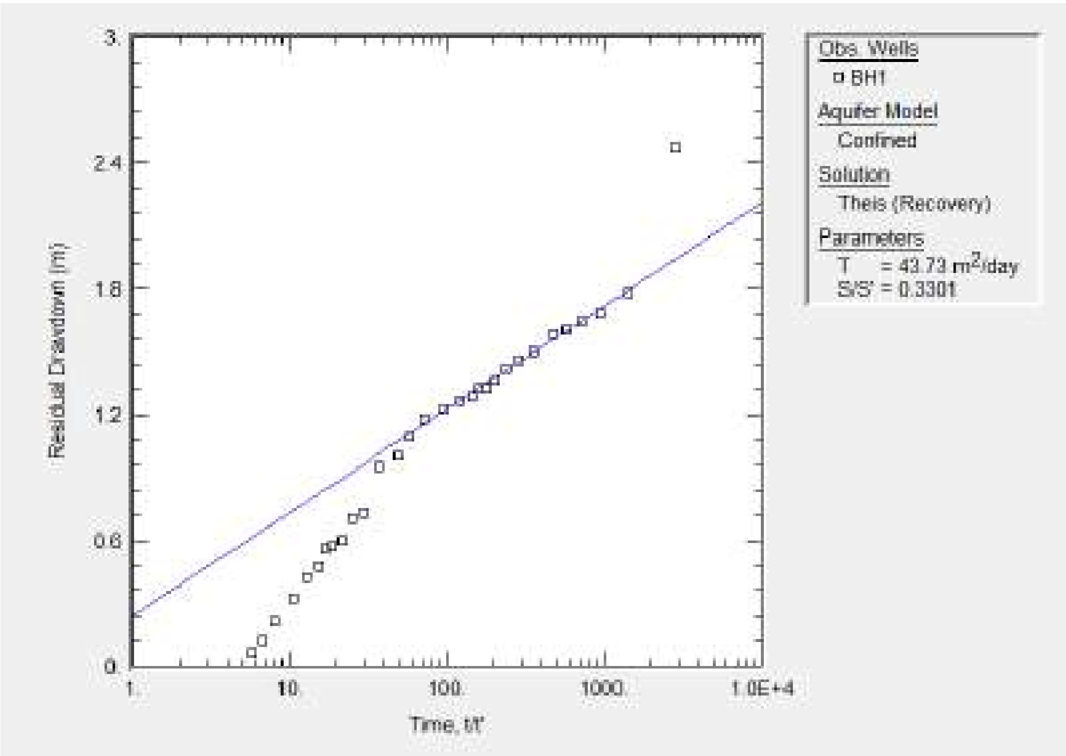
BH1 CDT2 Cooper-Jacob Early



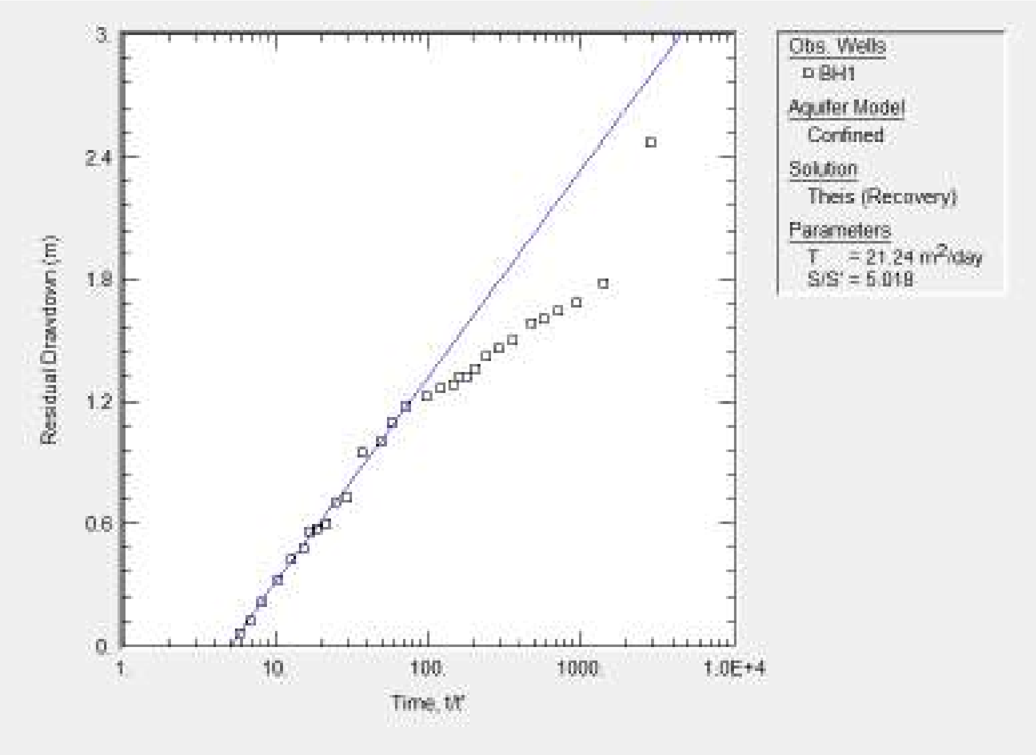
BH1 CDT2 Cooper-Jacob Late



BH1 CDT2 Theis



BH1 CDT2 Theis Recovery Early



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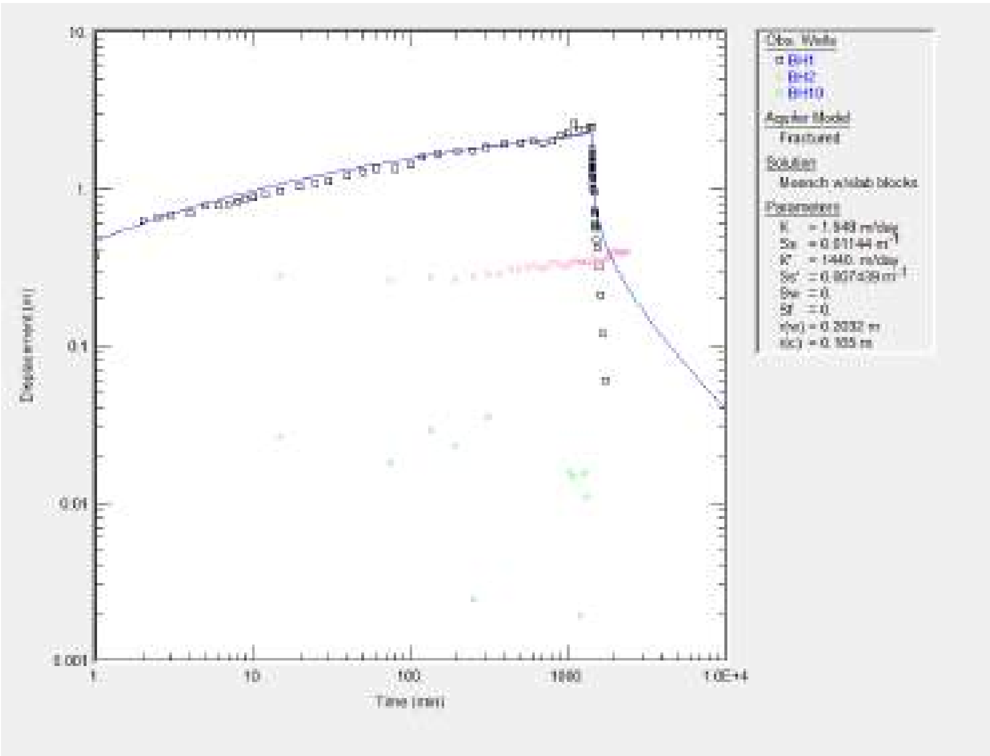
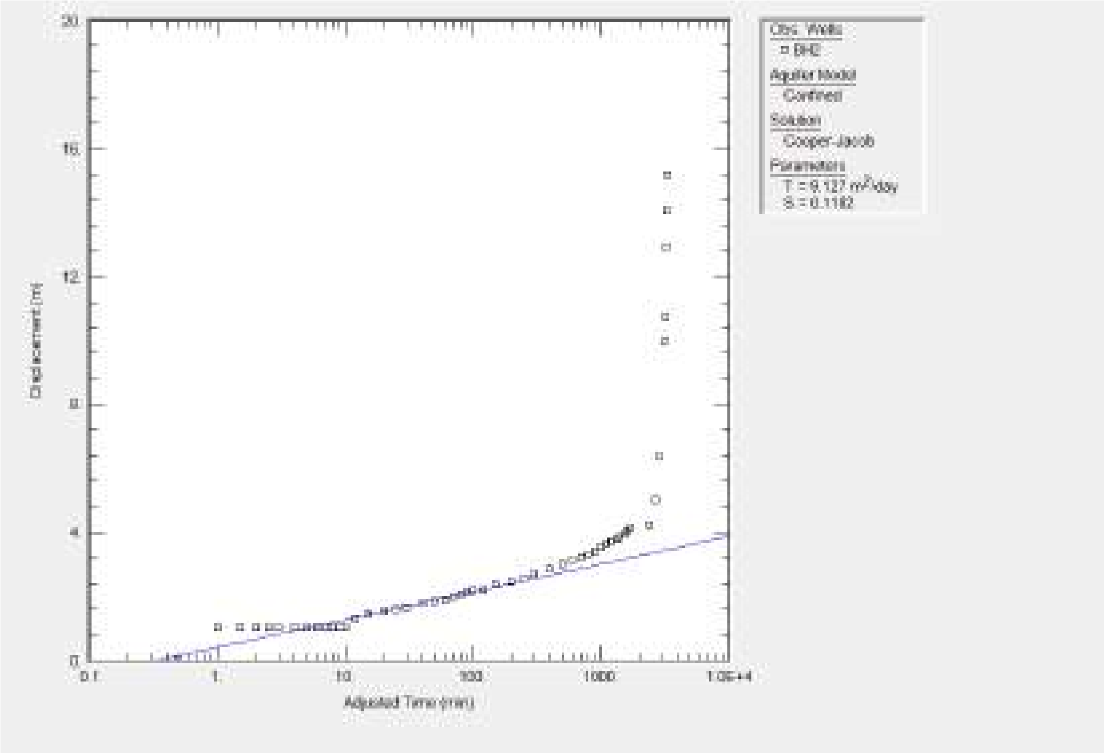
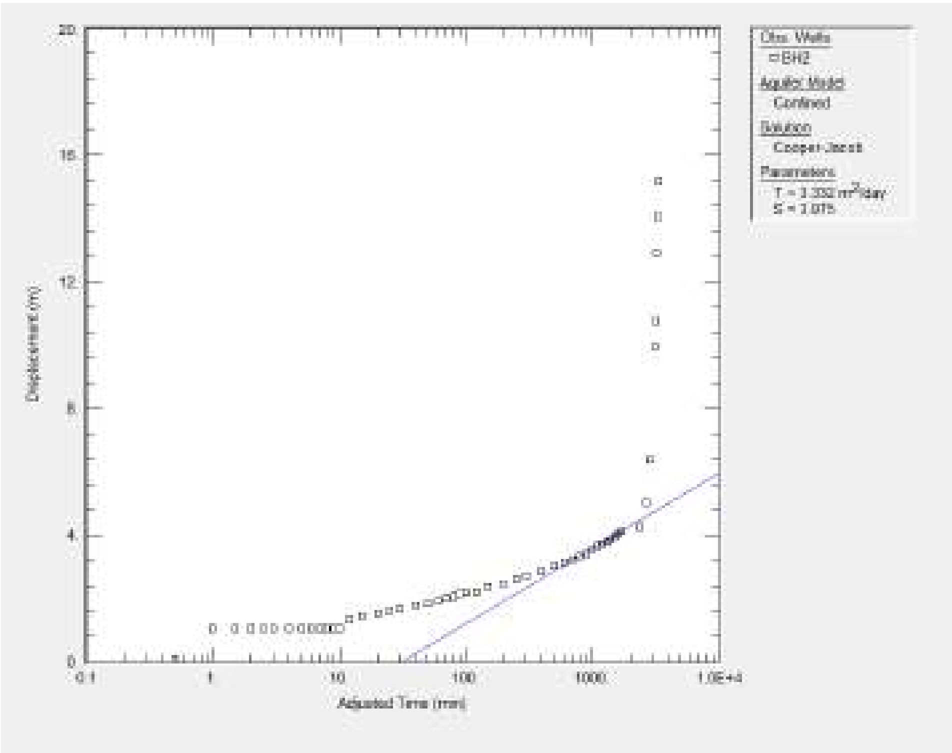


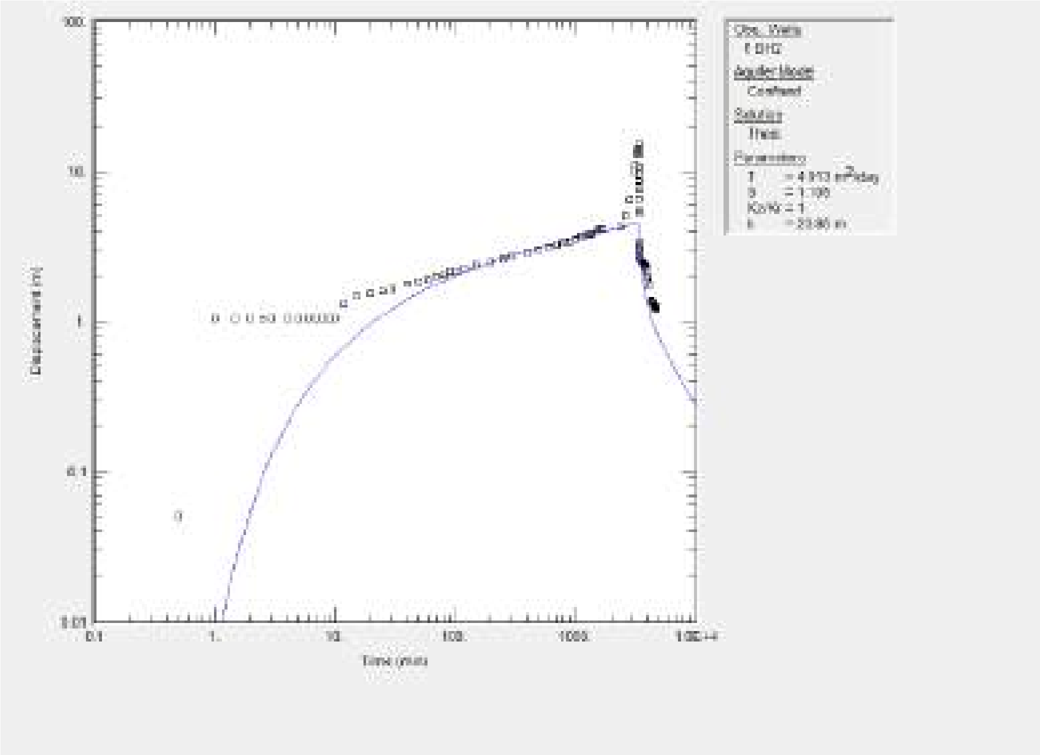
BH1 CDT2 Moench



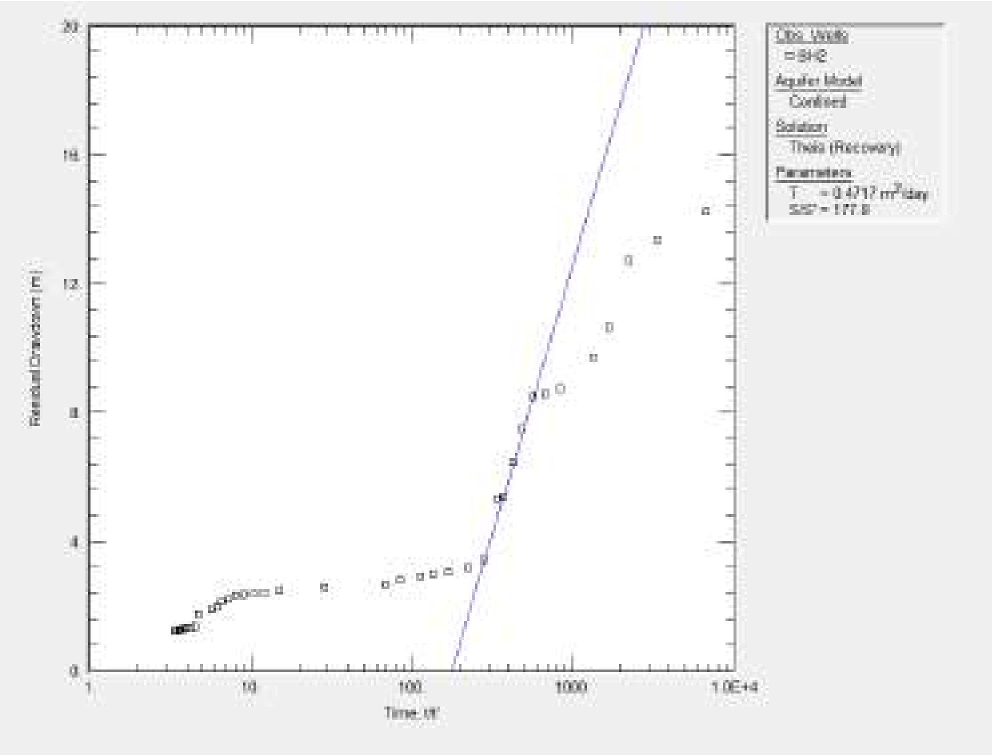
BH2 CDT1 Cooper-Jacob Early



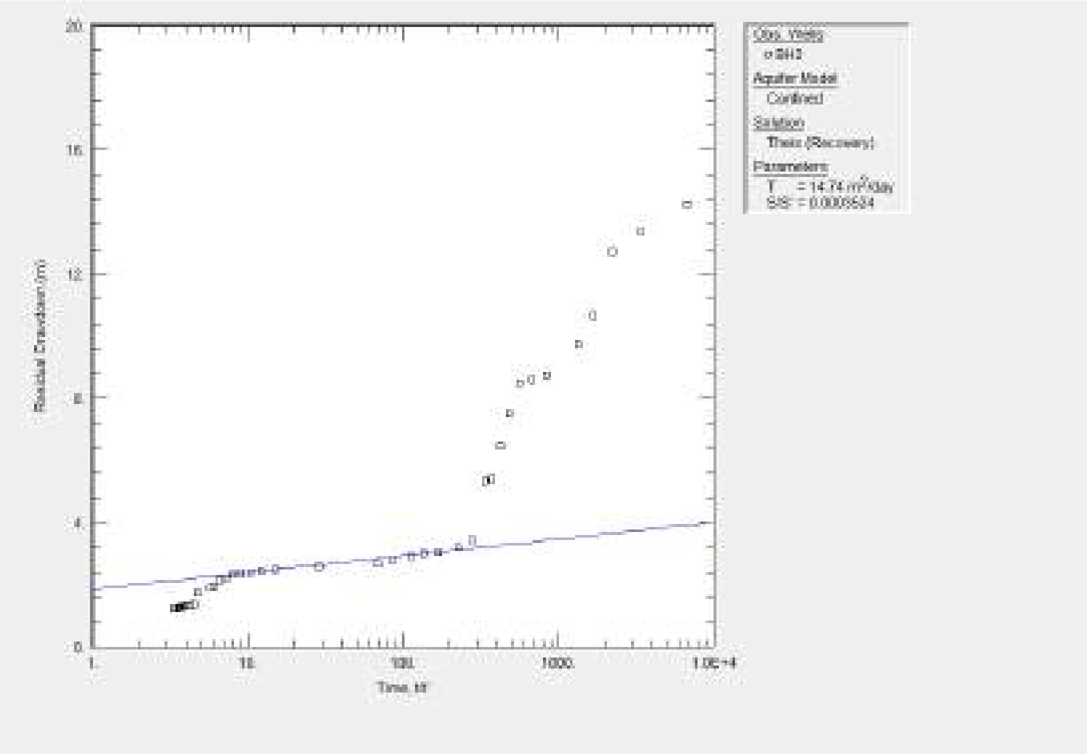
BH2 CDT1 Cooper-Jacob Late



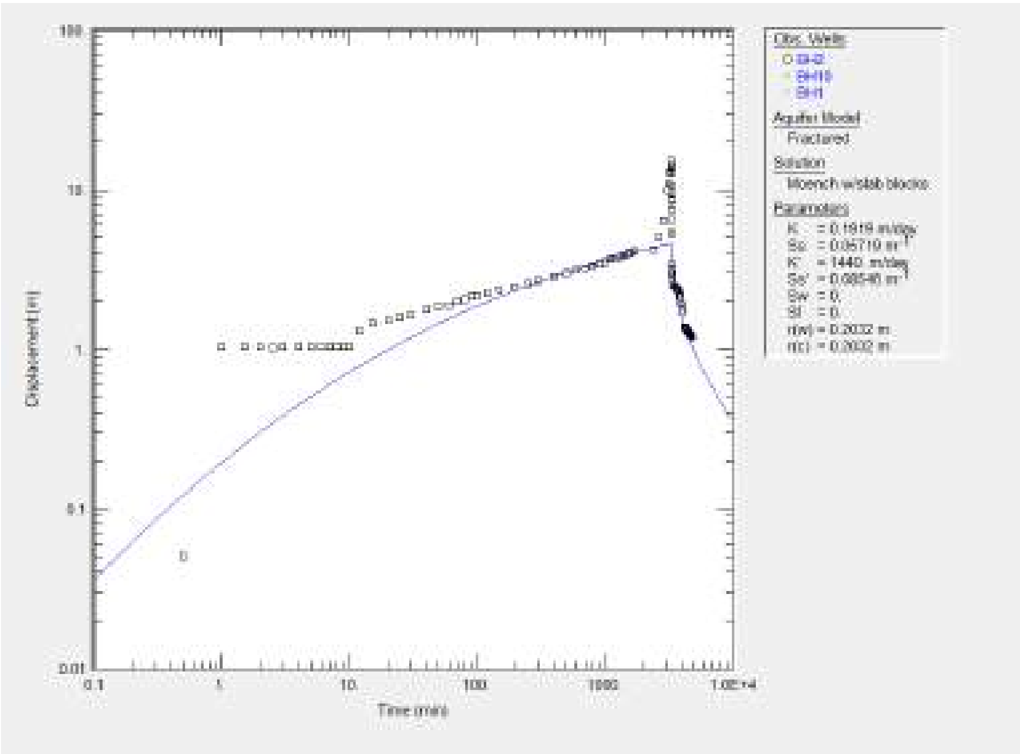
BH2 CDT1 Theis



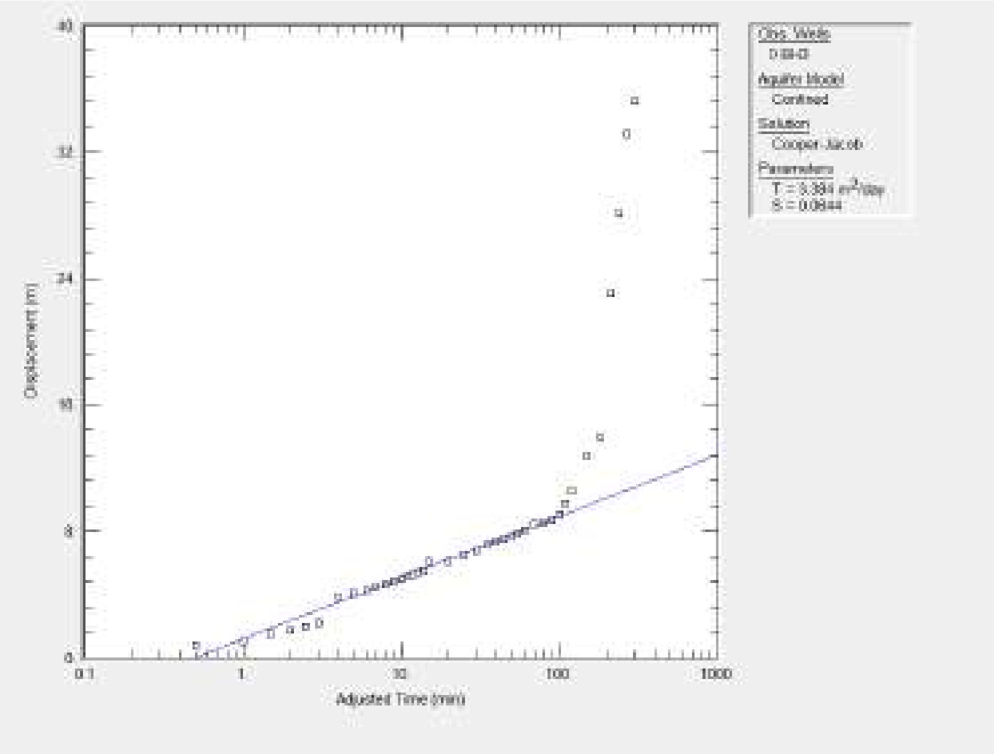
BH2 CDT1 Theis Recovery Early



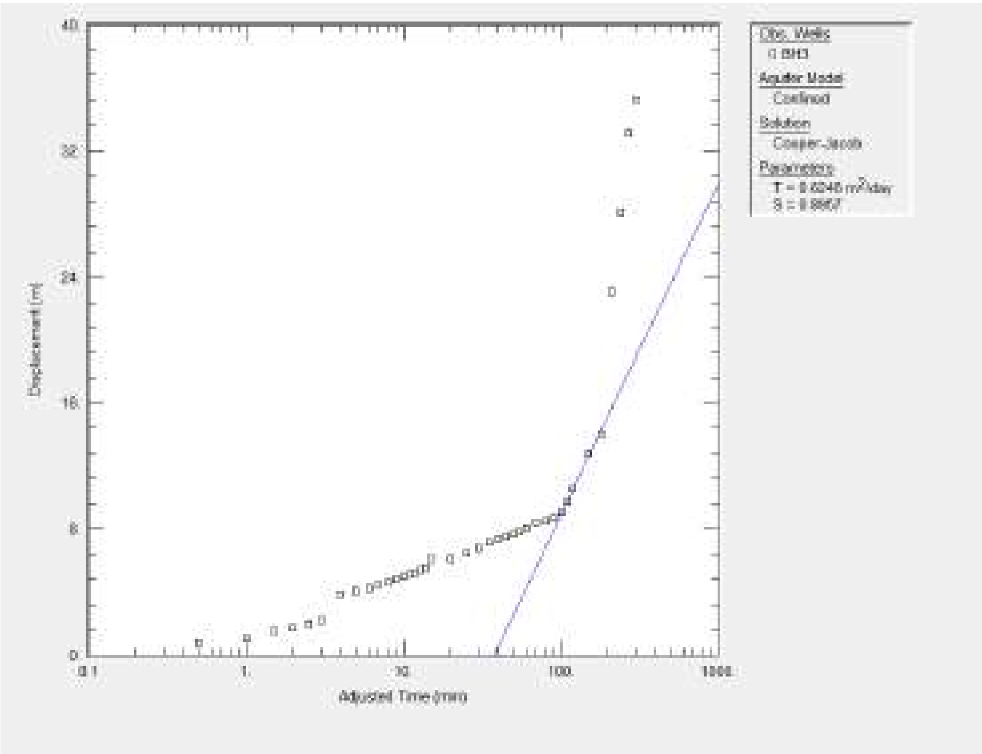
BH2 CDT1 Theis Recovery Late



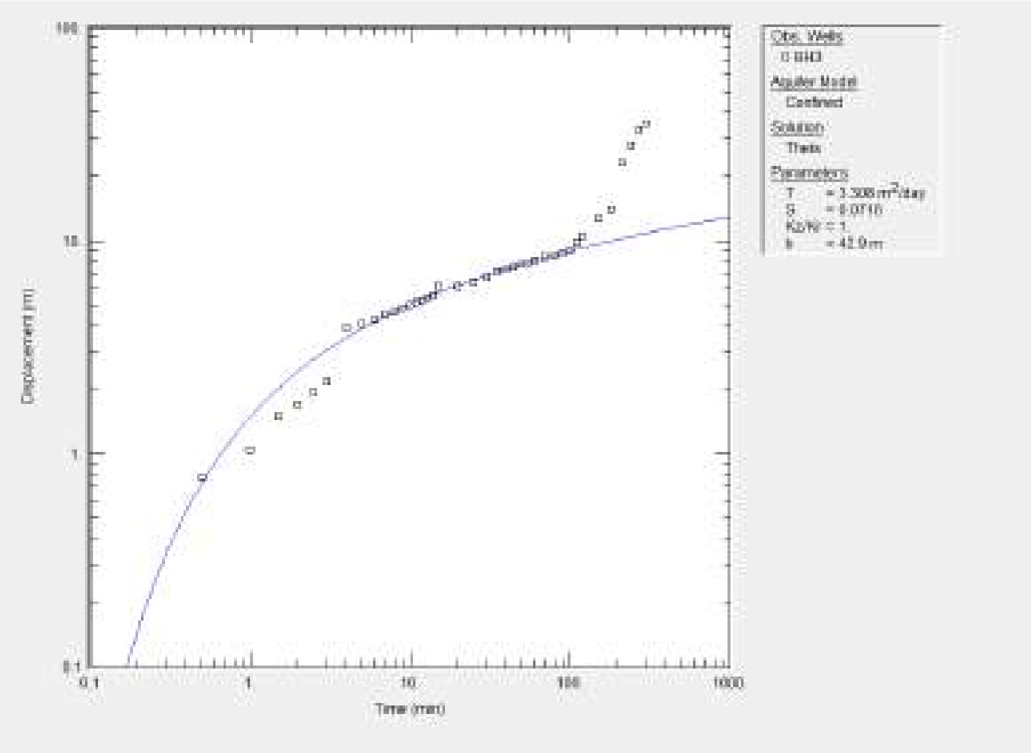
BH2 CDT1 Moench



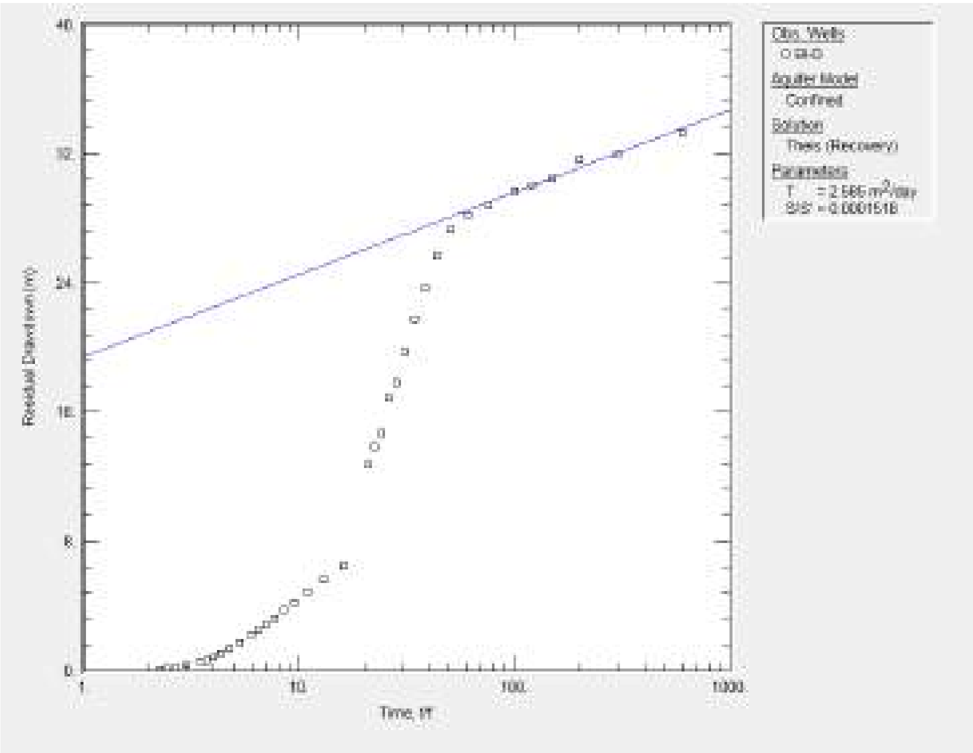
BH3 CDT1 Cooper-Jacob Early



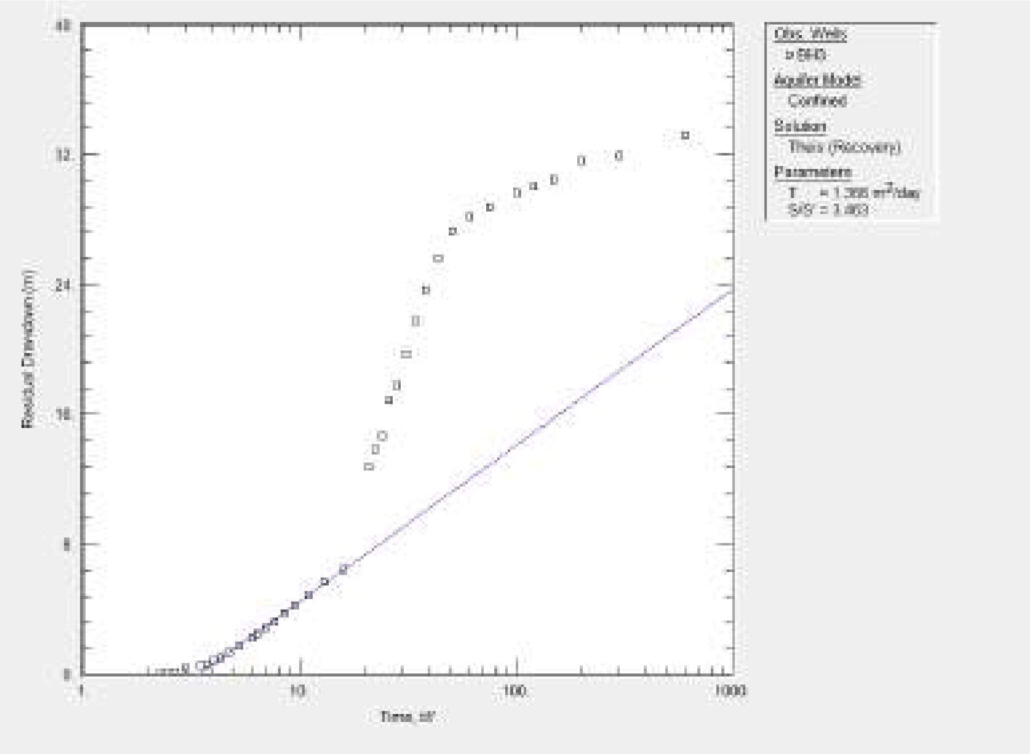
BH3 CDT1 Cooper-Jacob Late



BH3 CDT1 Theis



BH3 CDT1 Theis Recovery Early



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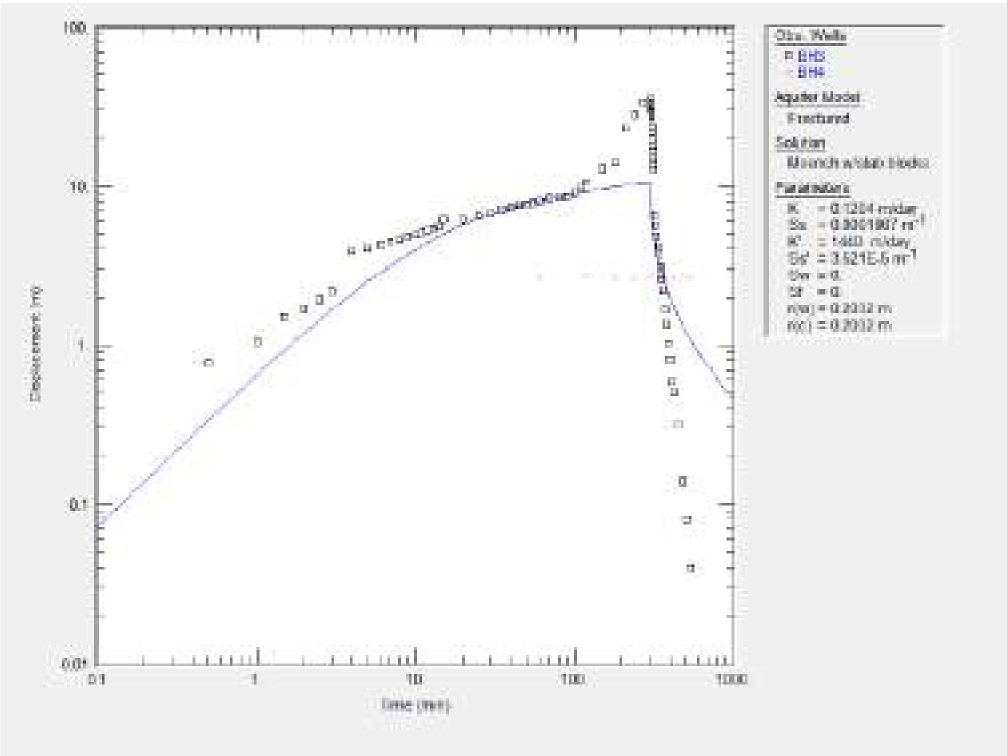
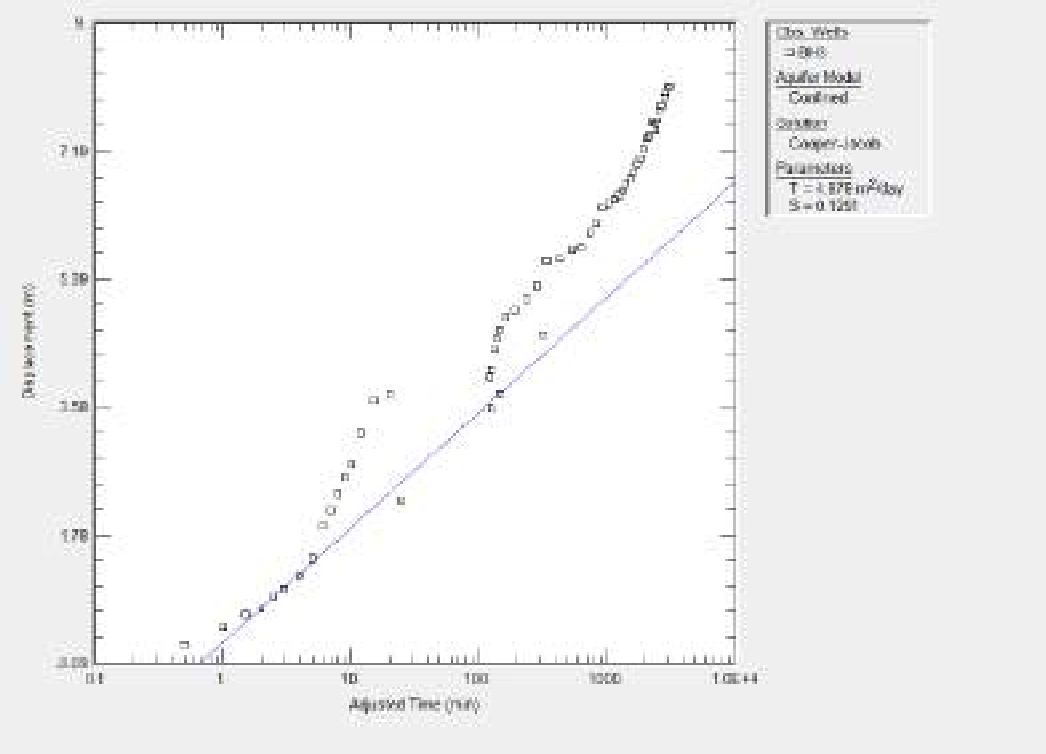
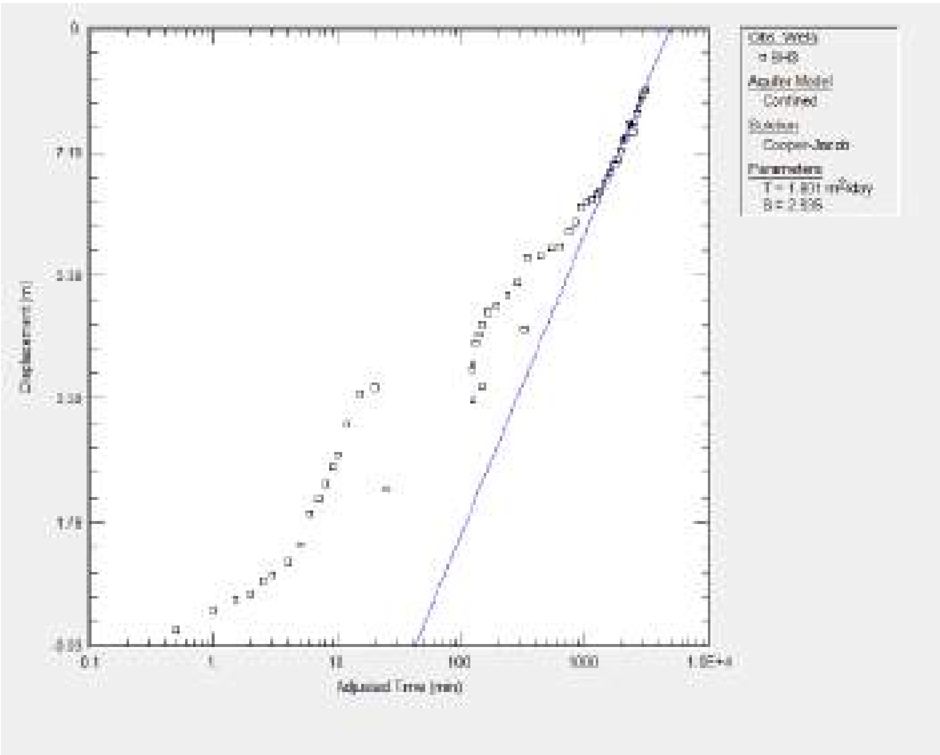


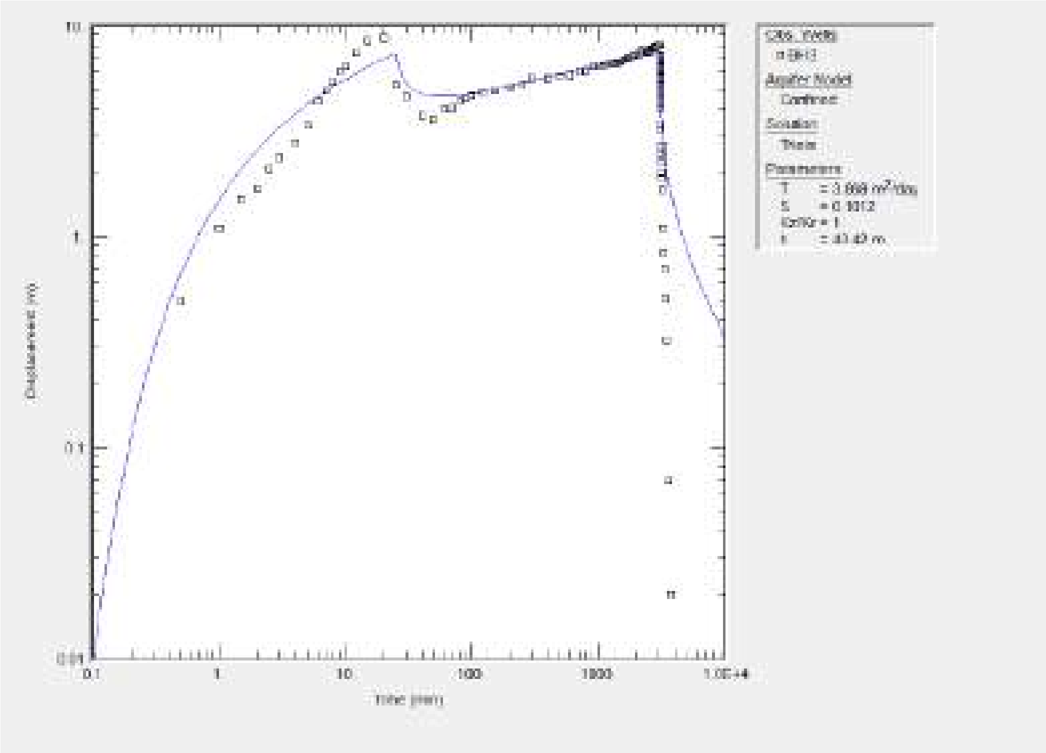
BH3 CDT1 Moench



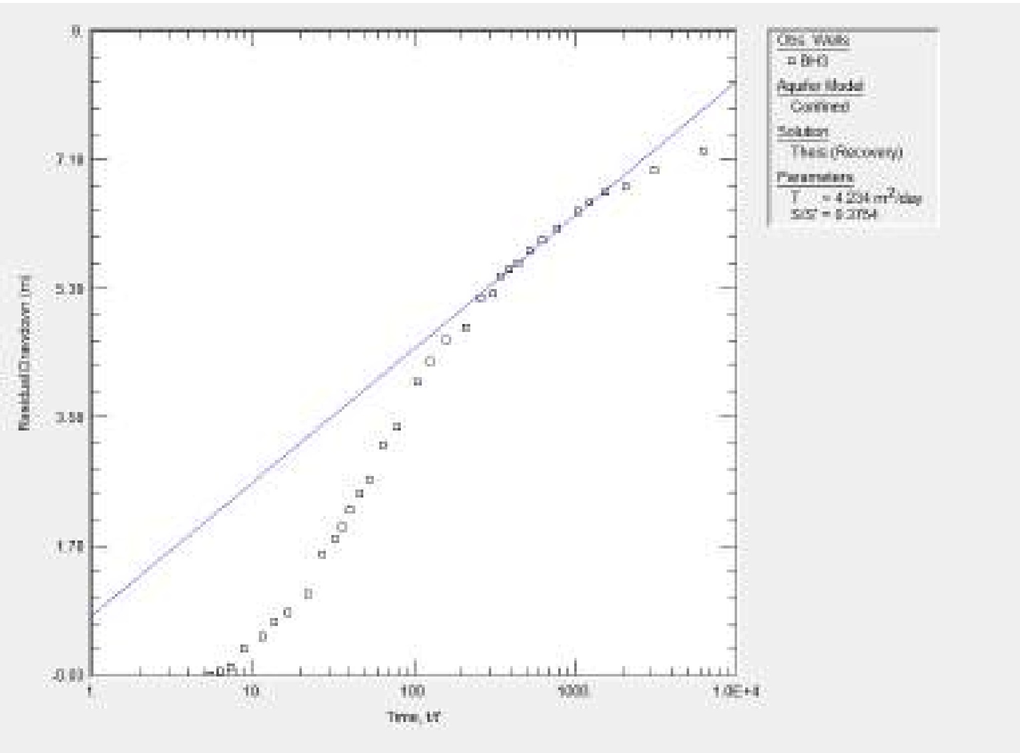
BH3 CDT2 Cooper-Jacob Early



BH3 CDT2 Cooper-Jacob Late



BH3 CDT2 Theis



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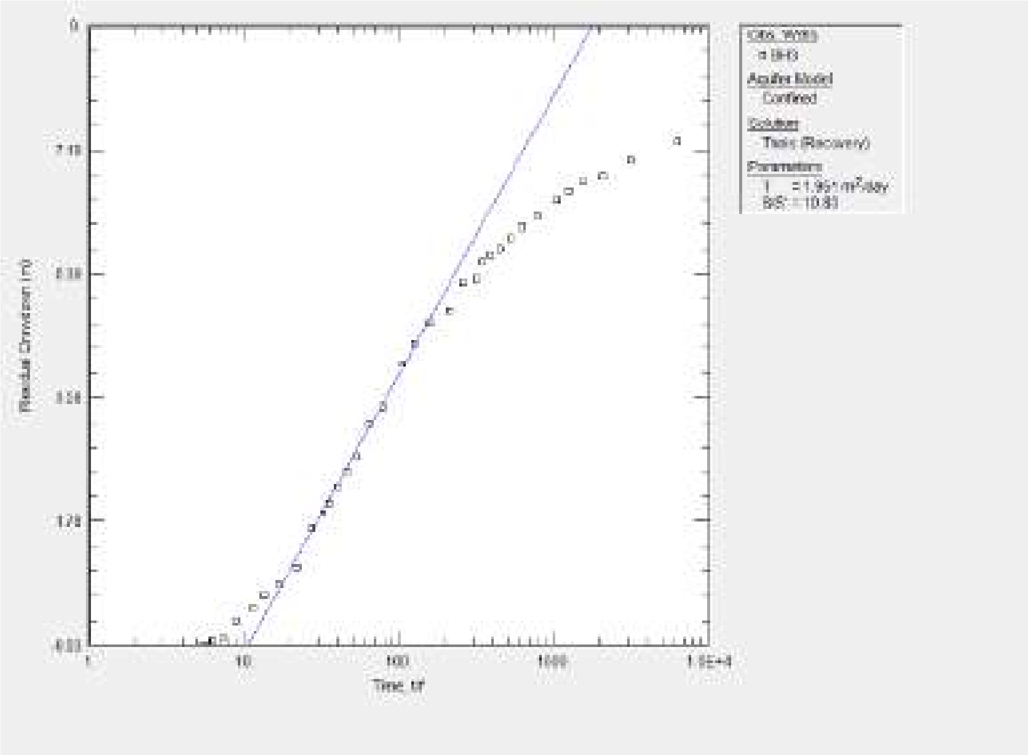

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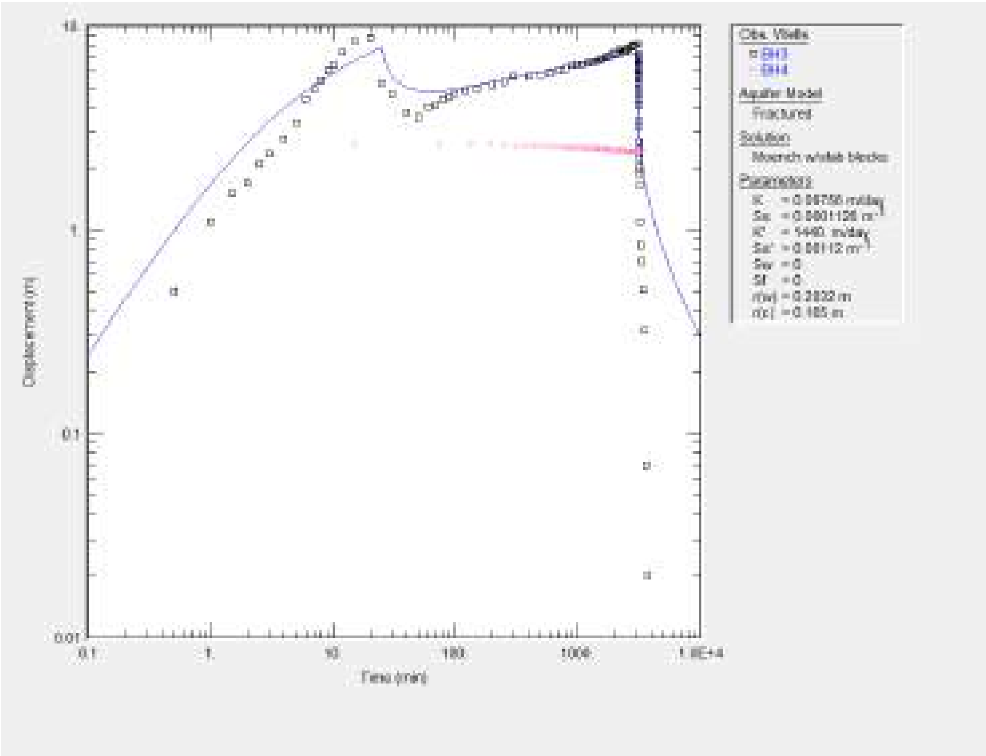

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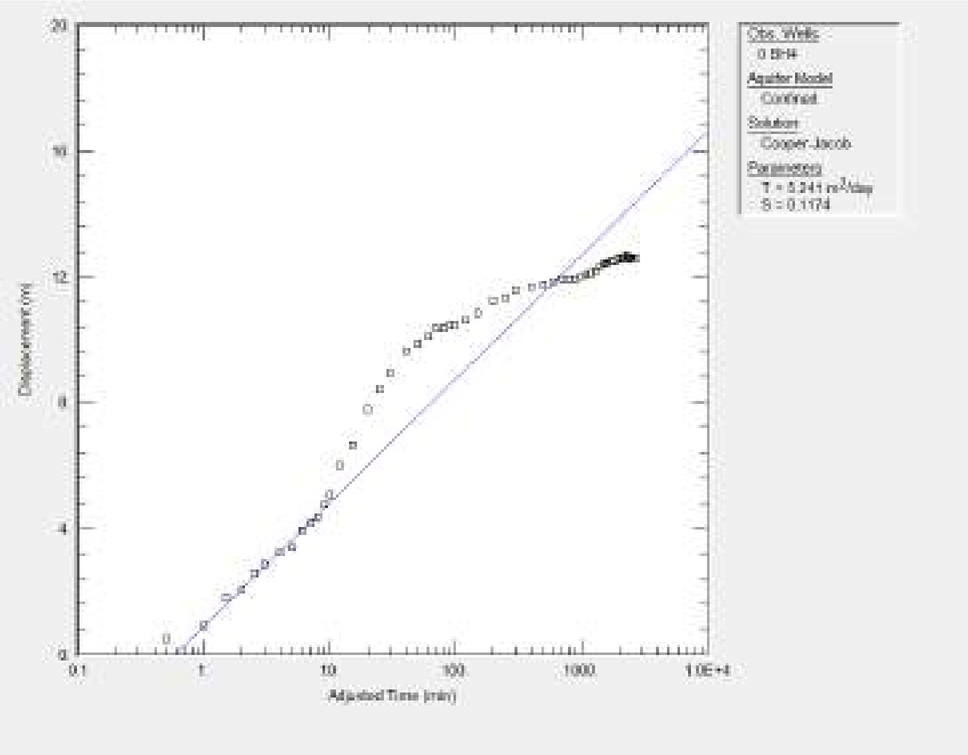

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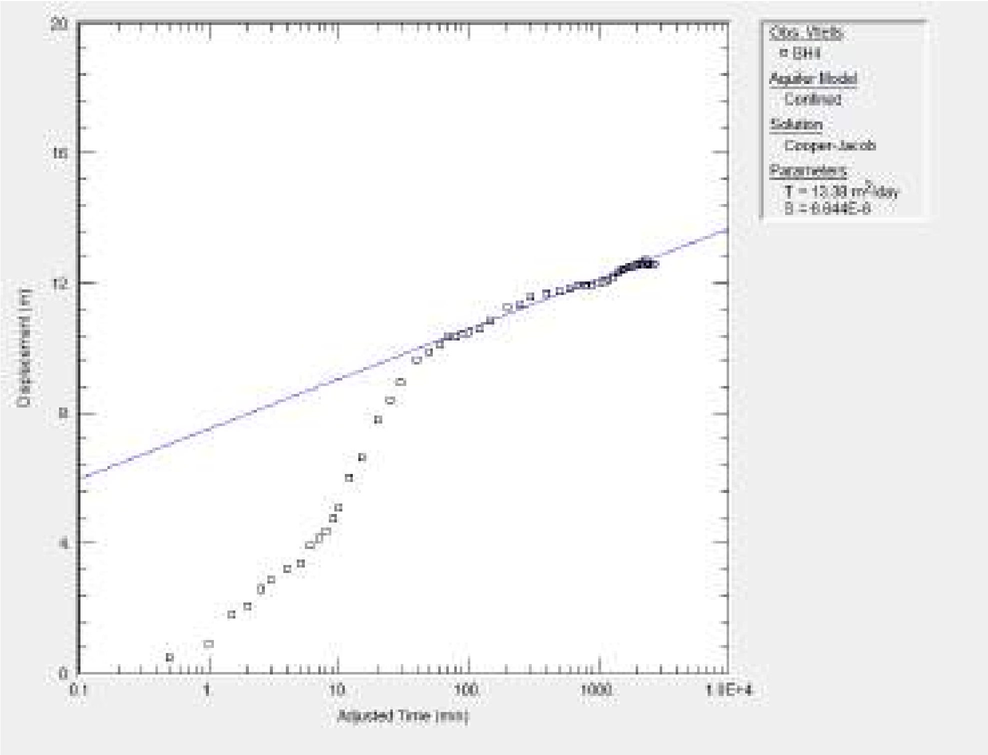

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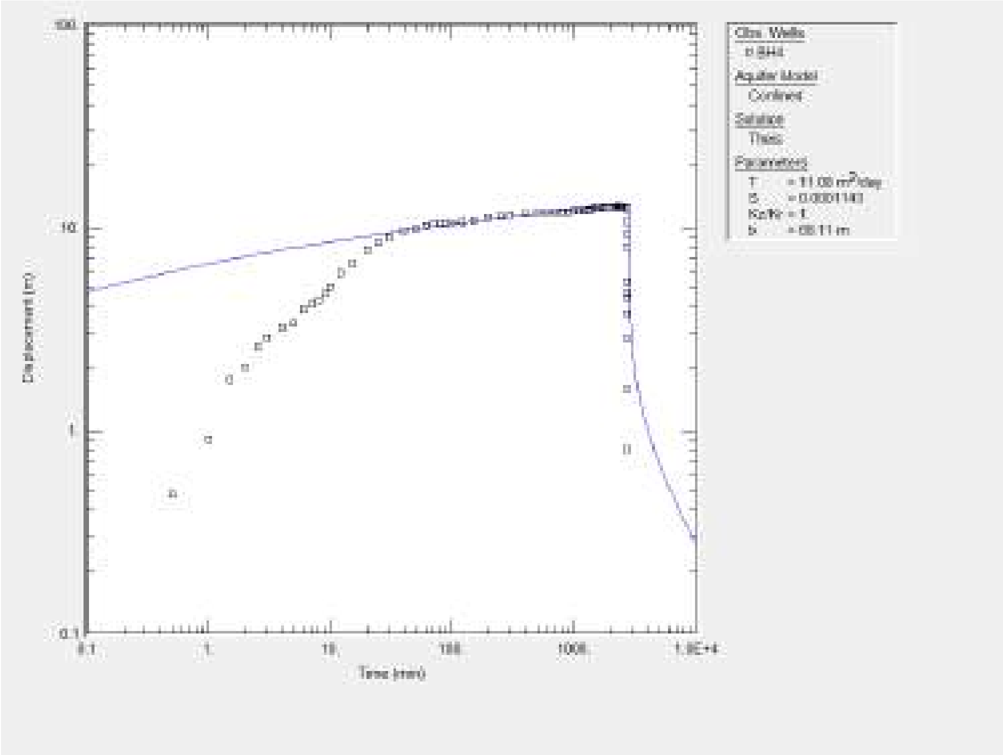

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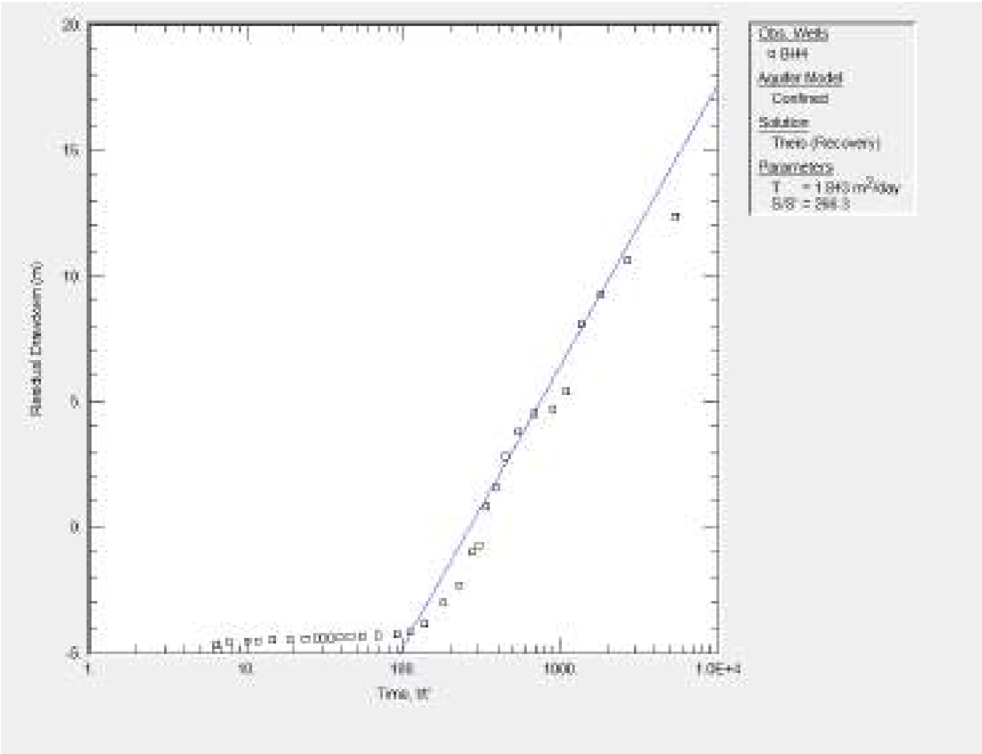

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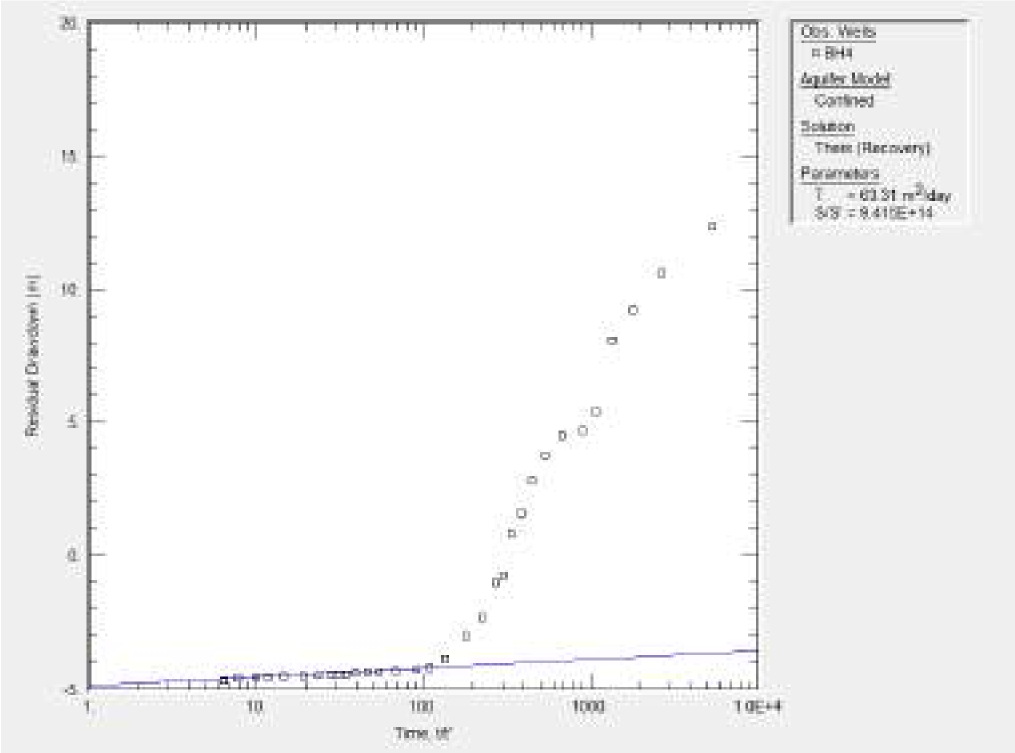

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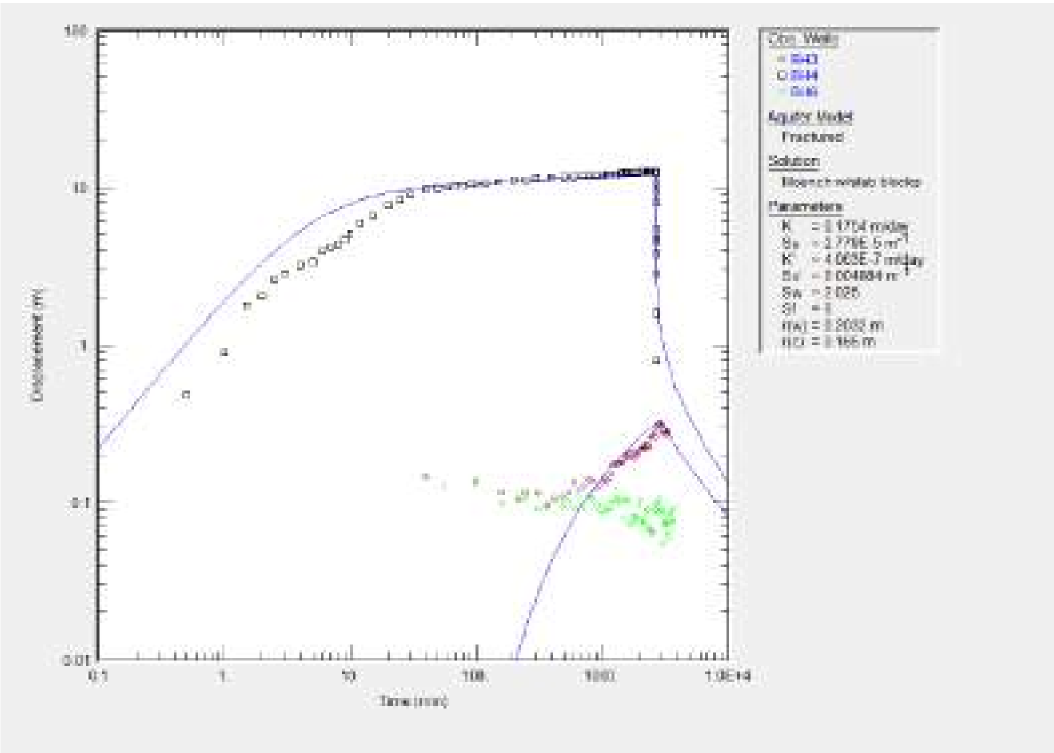

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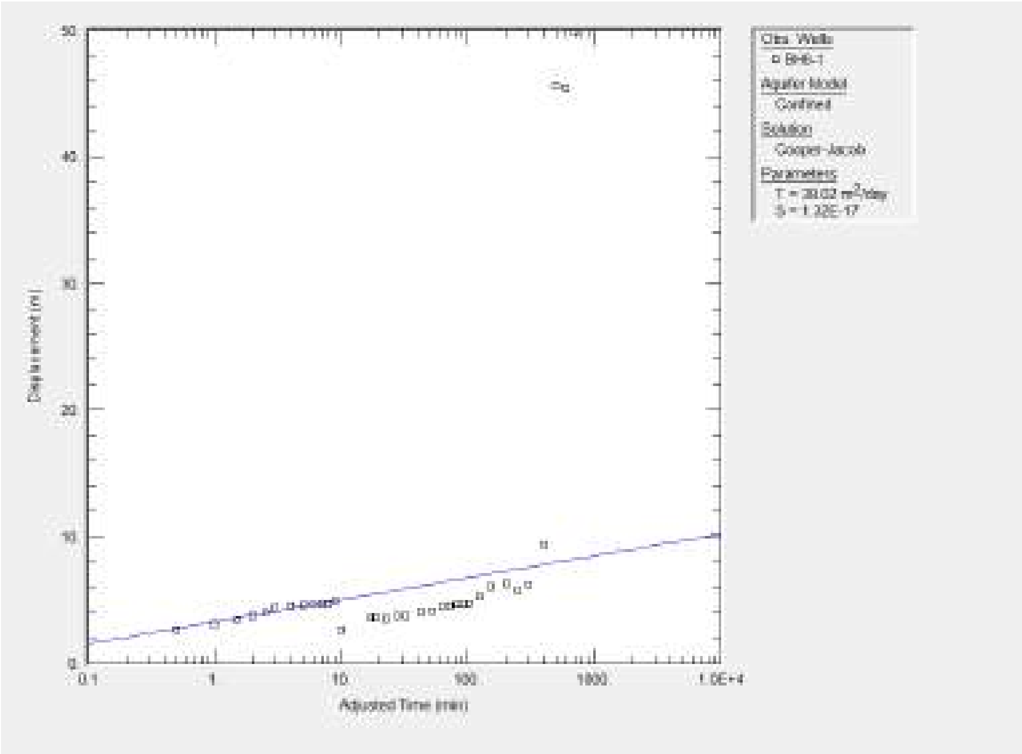

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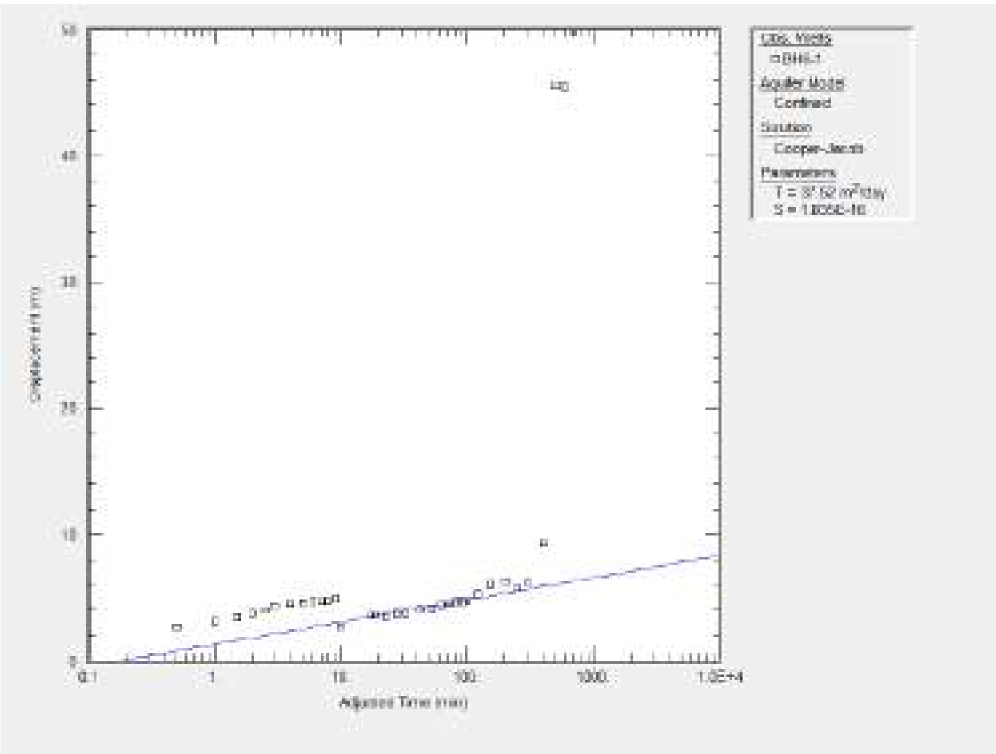

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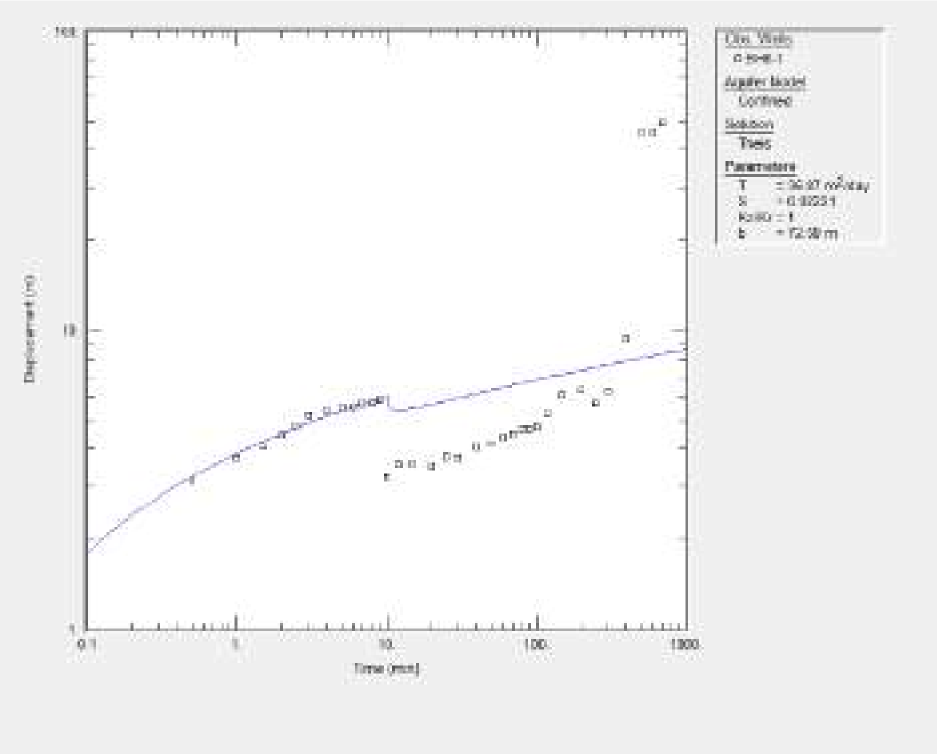

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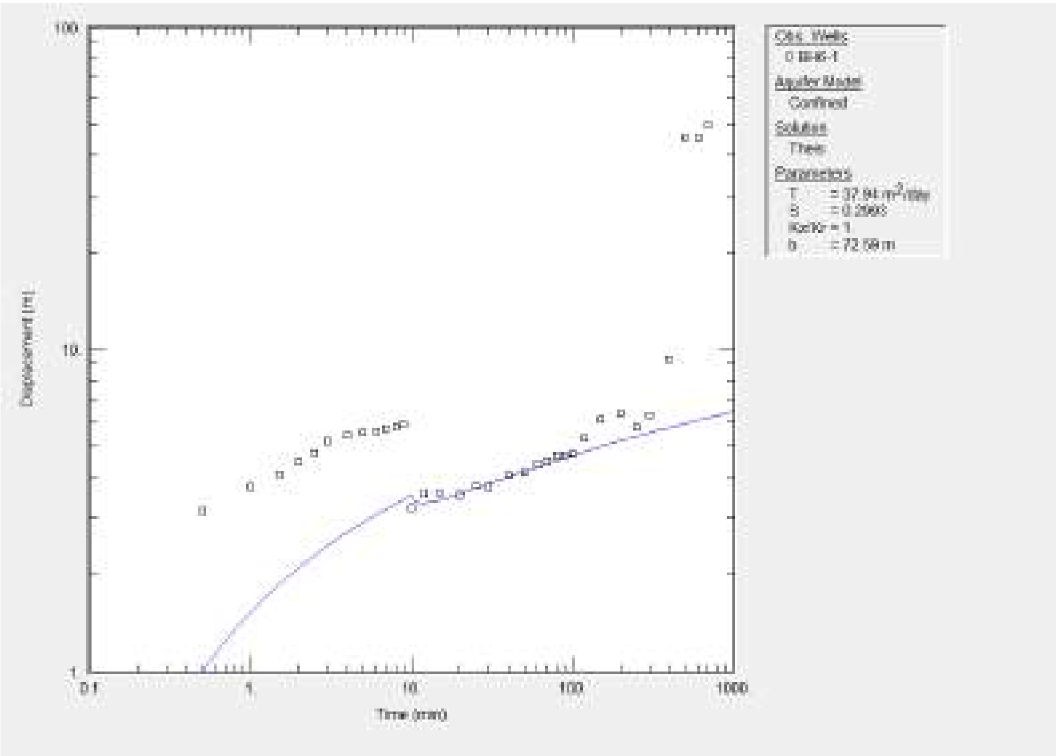

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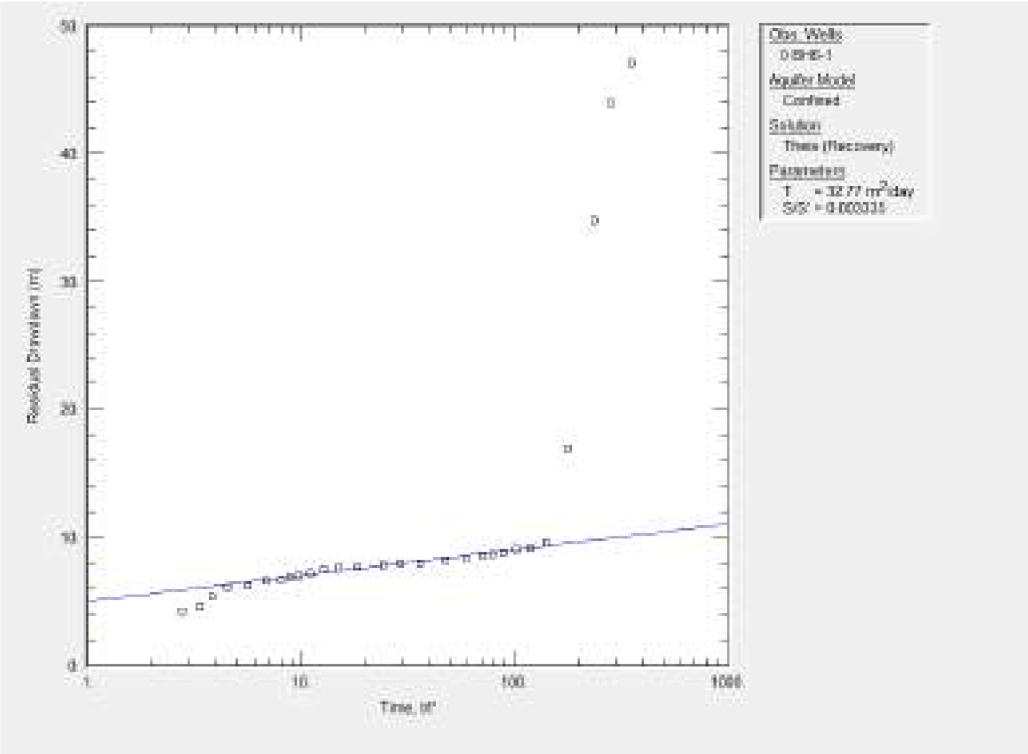

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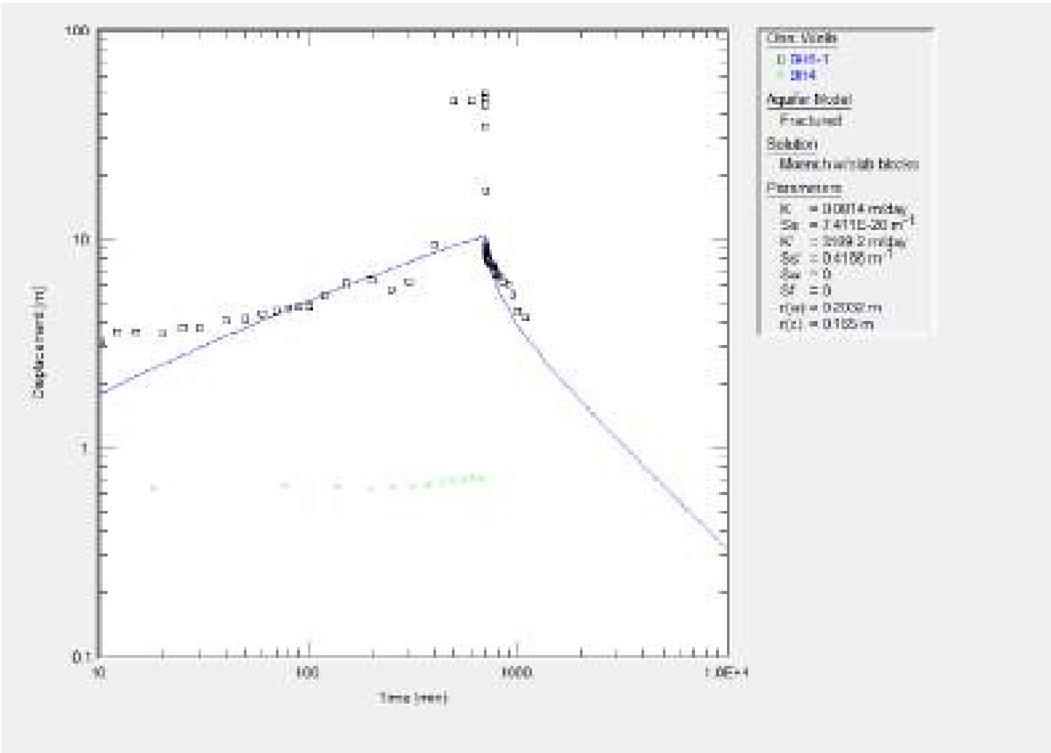

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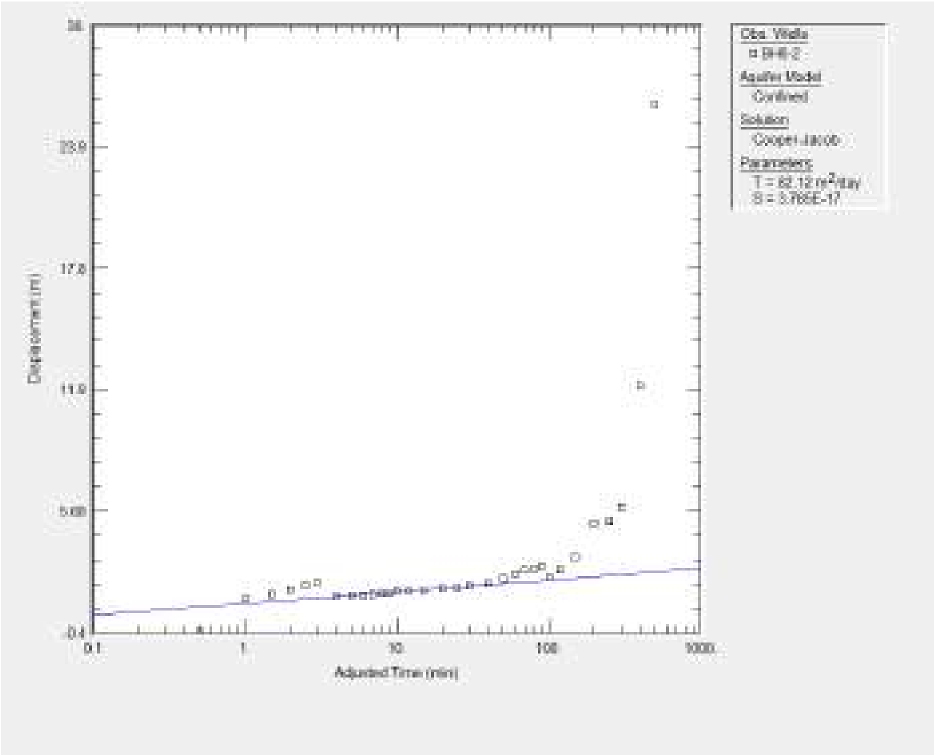

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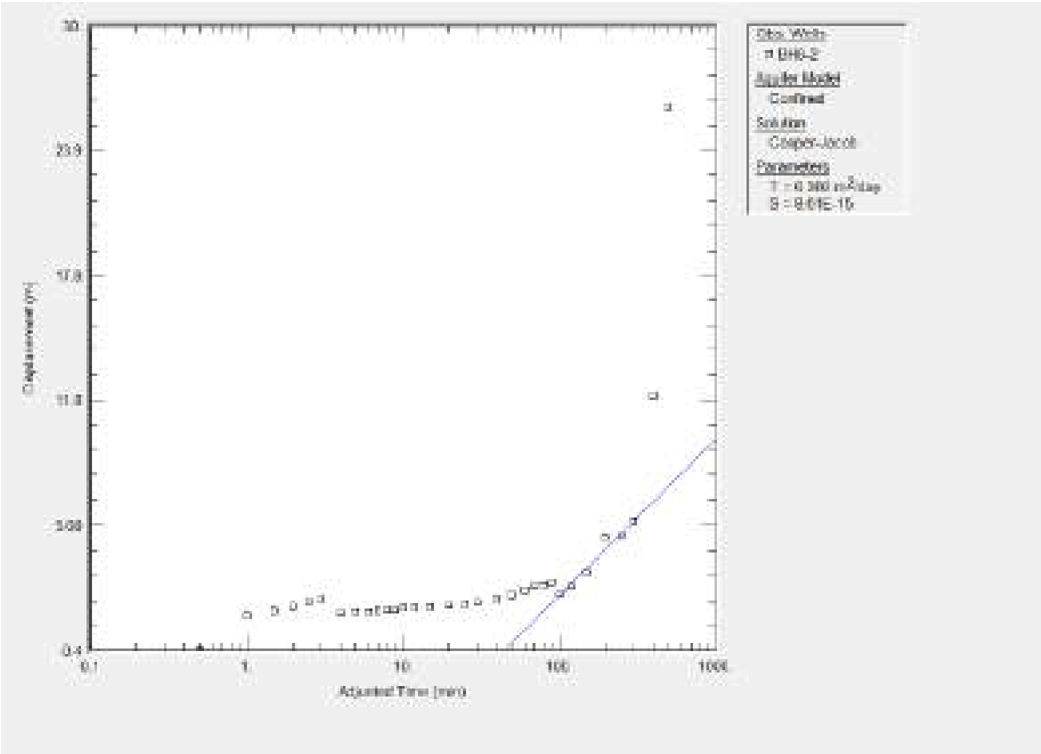

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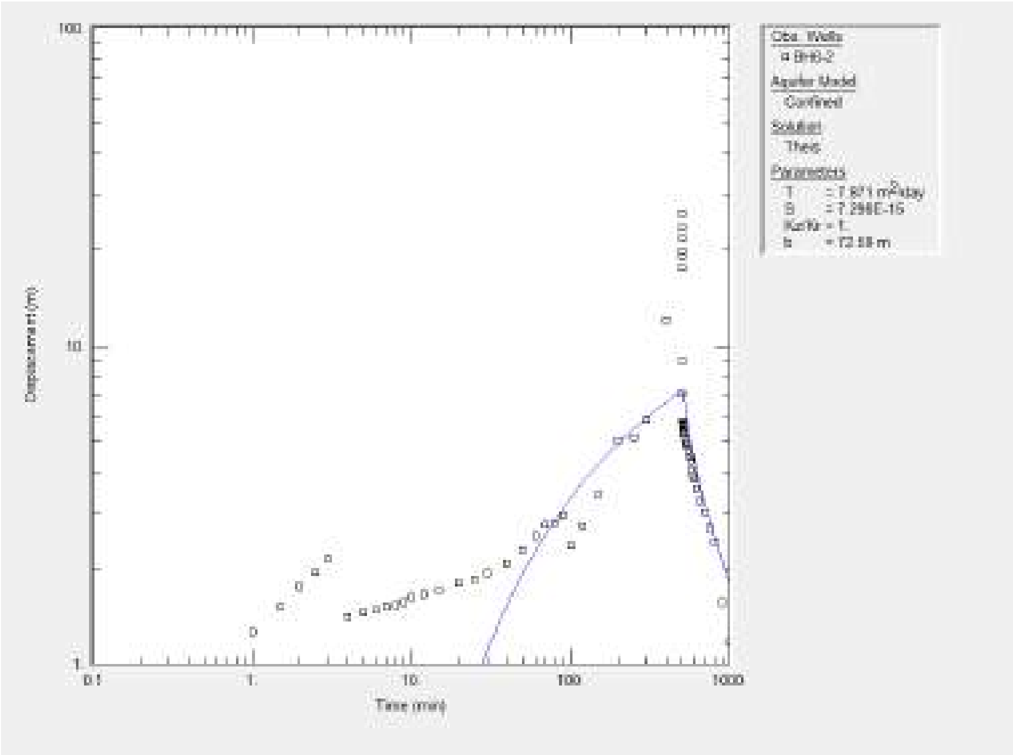

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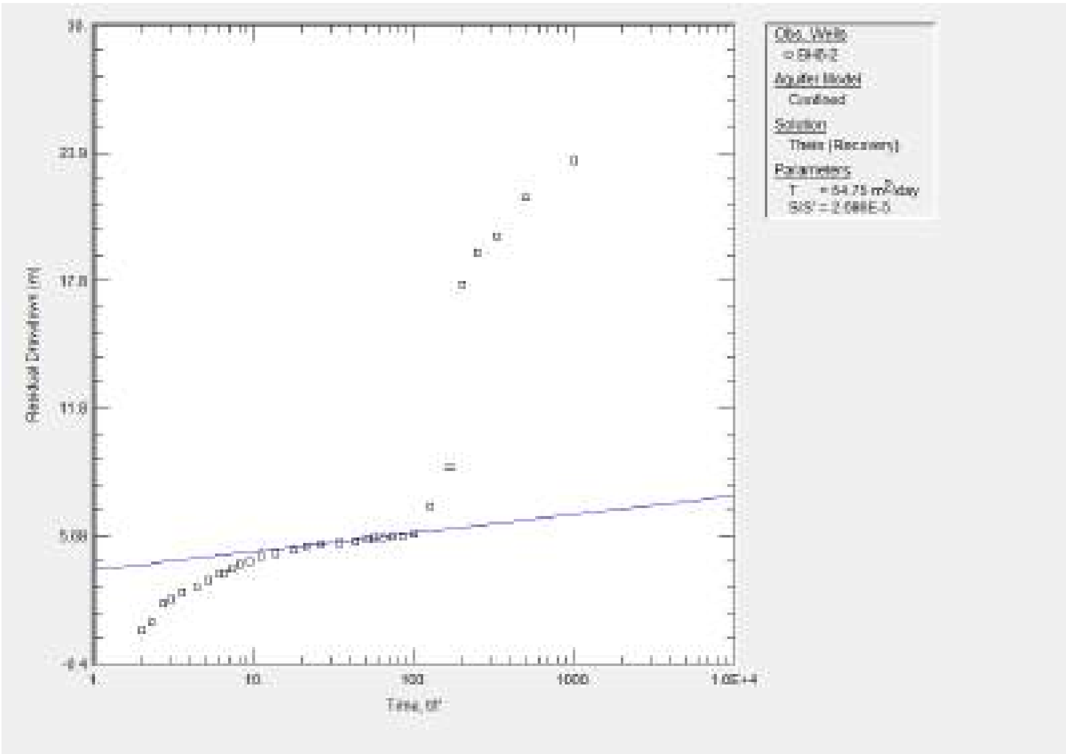

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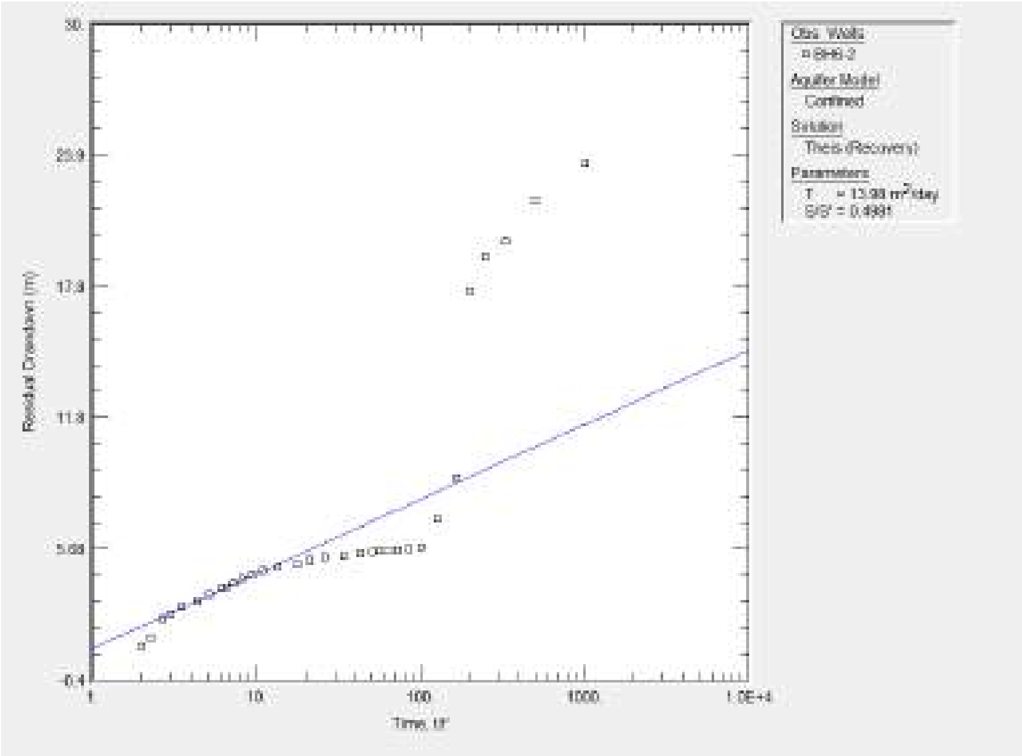

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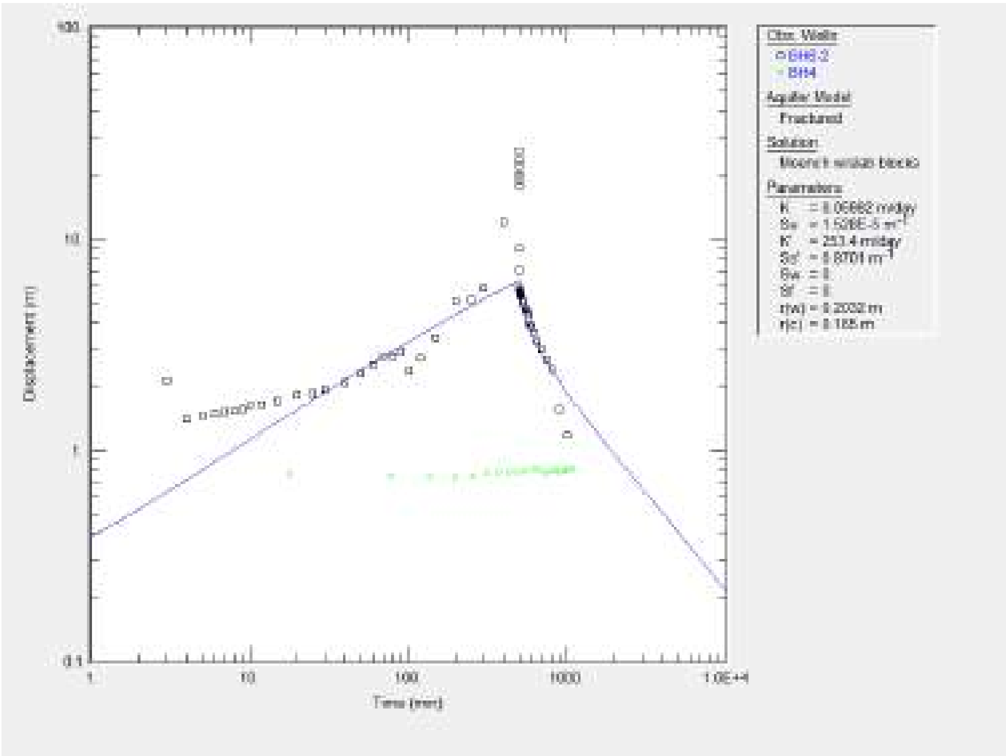

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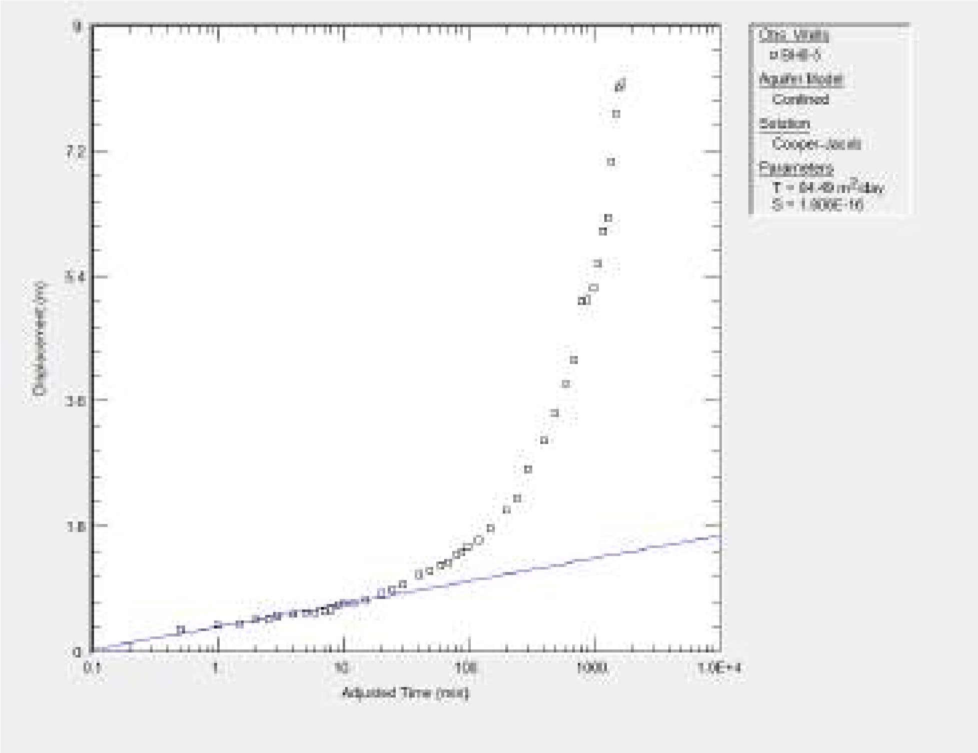

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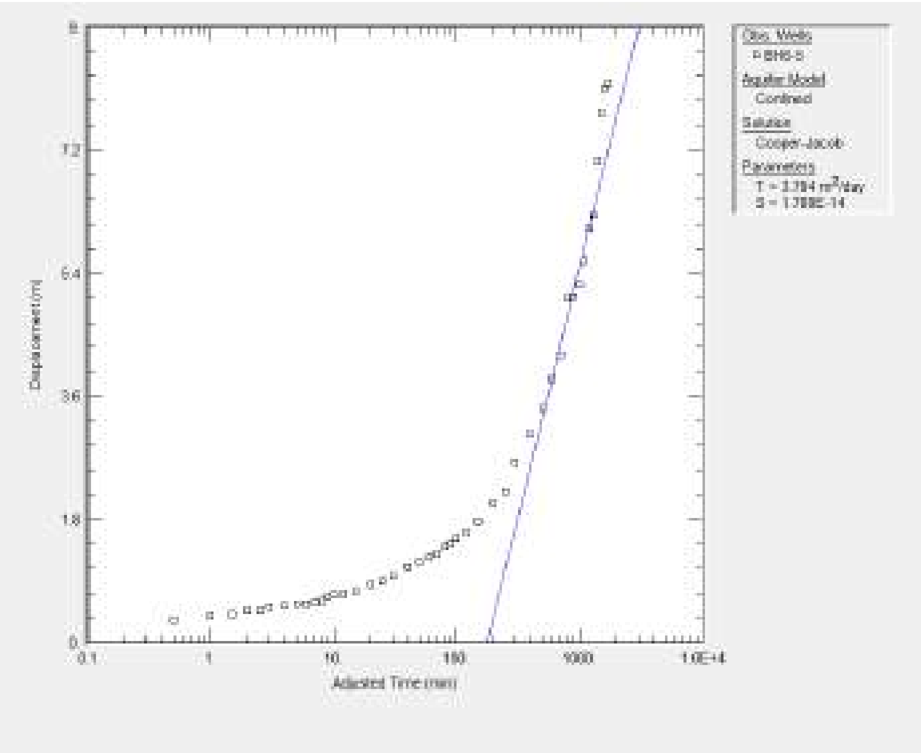

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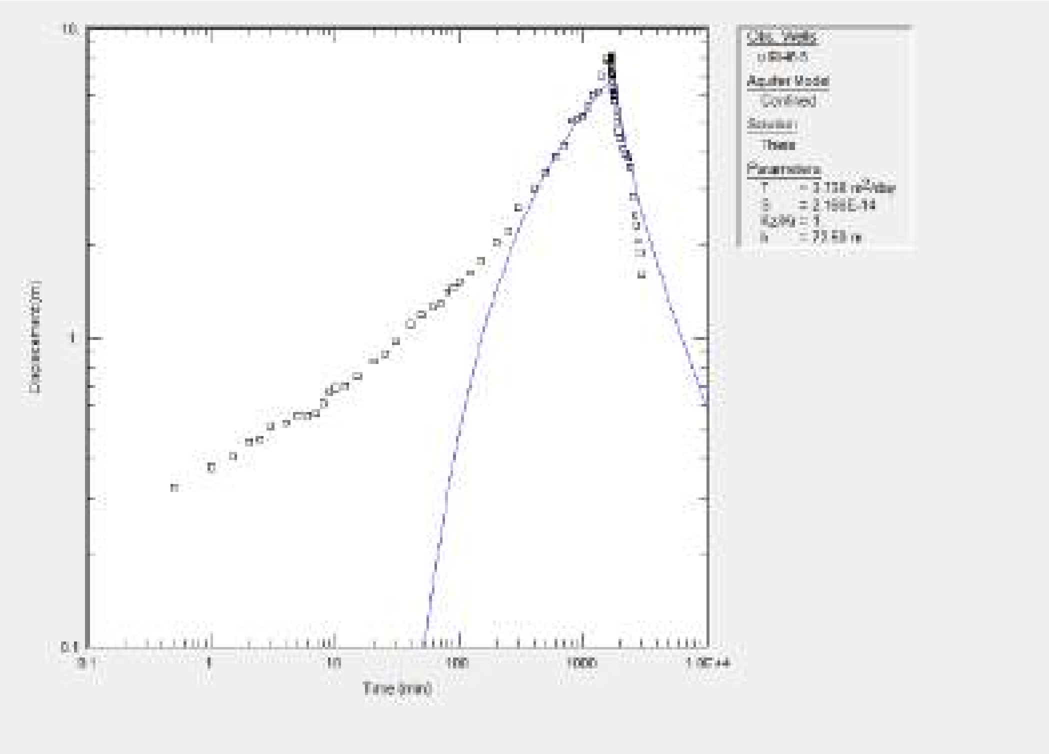

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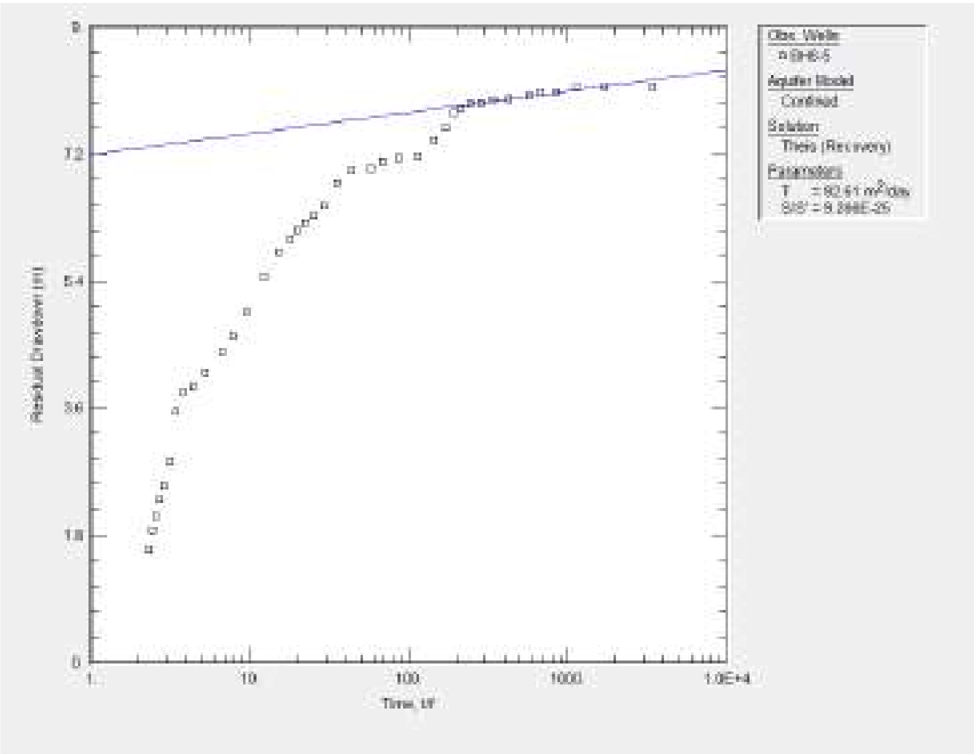

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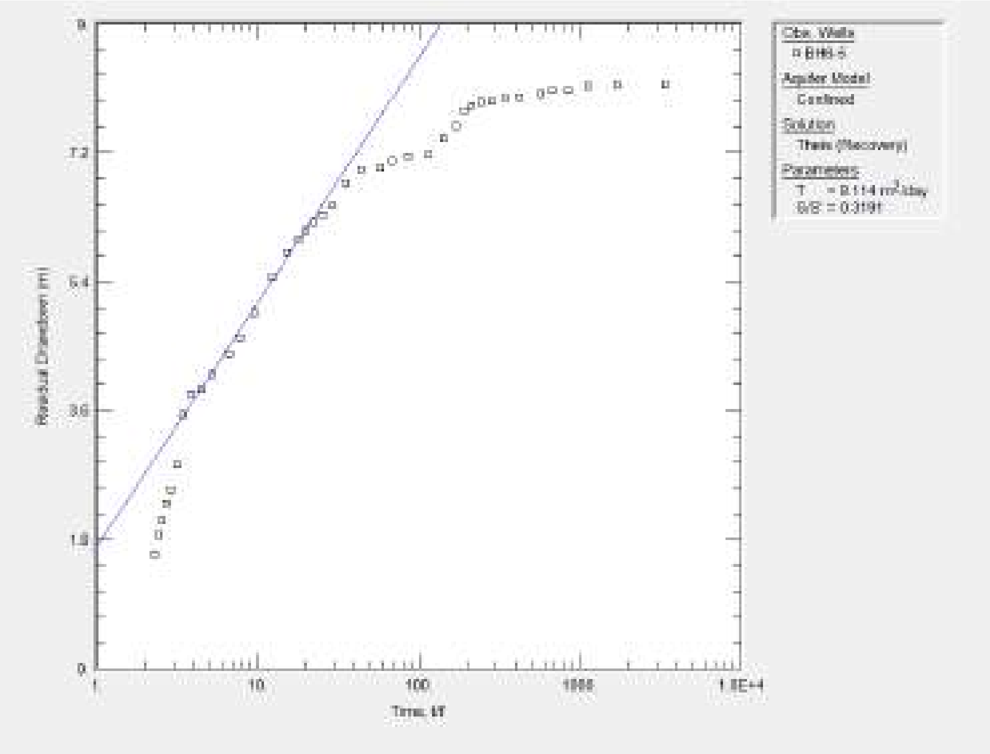

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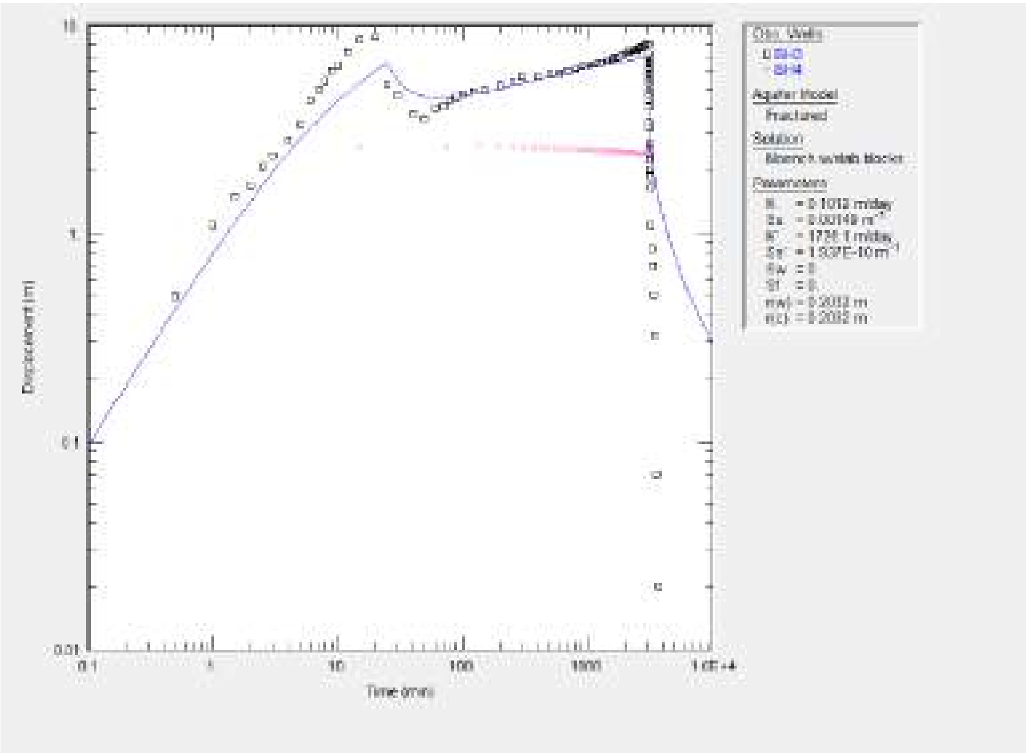

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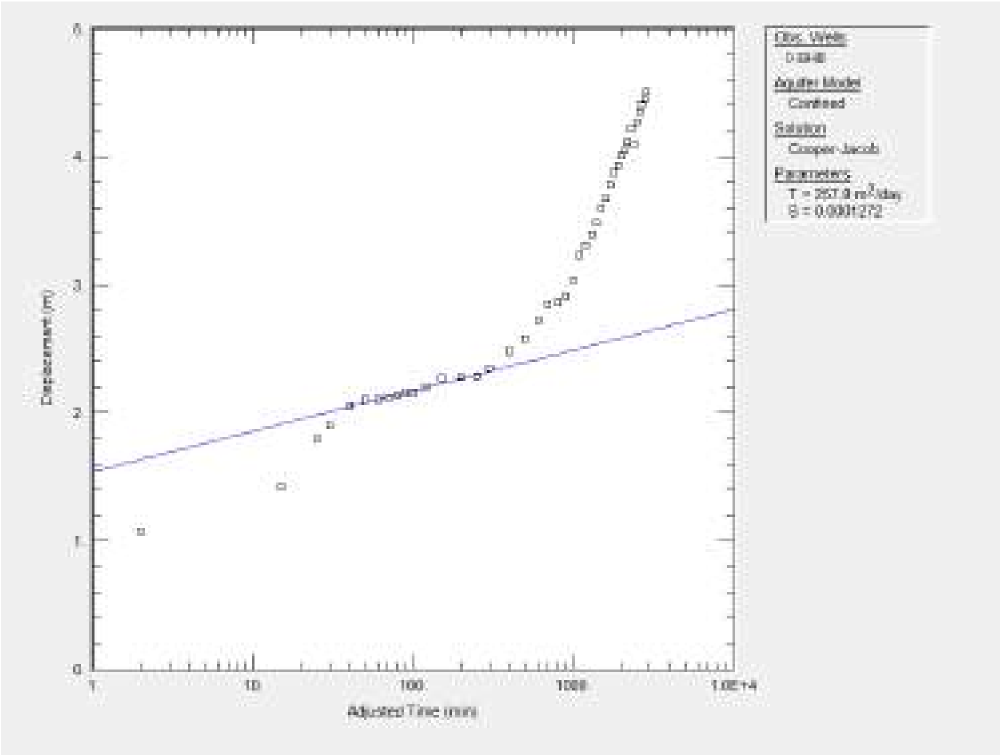

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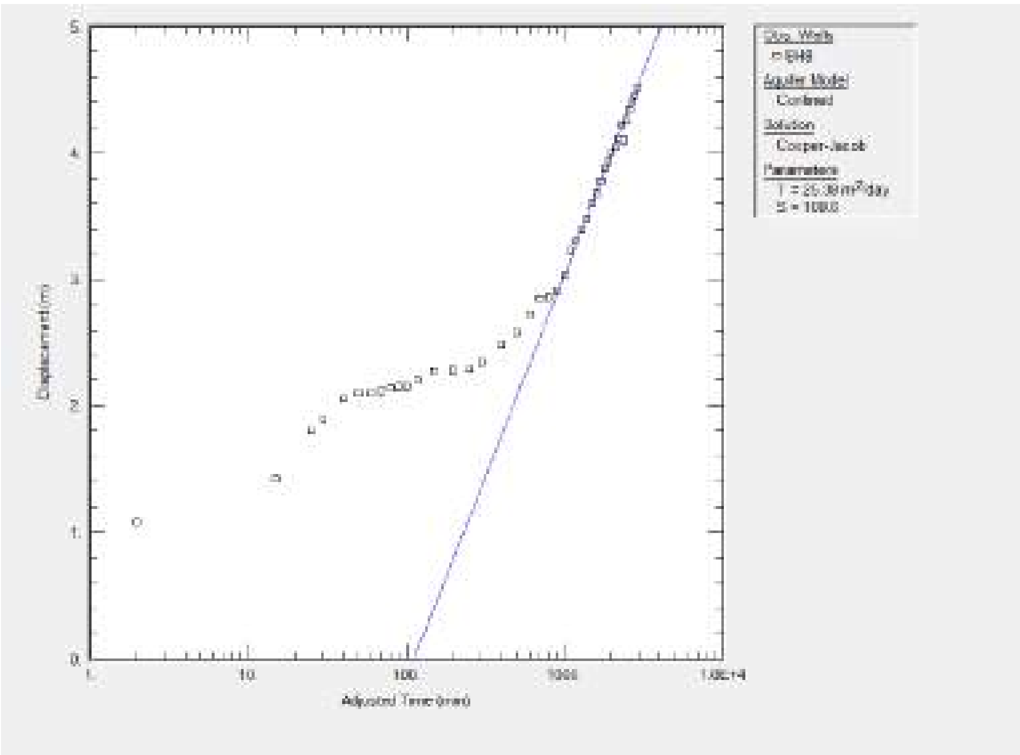

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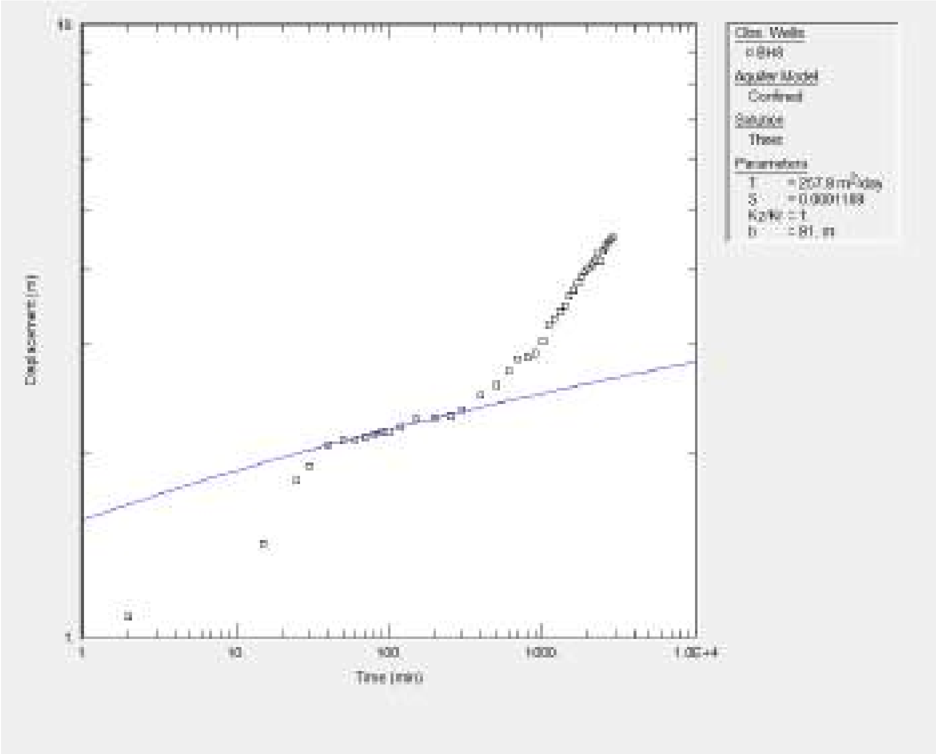

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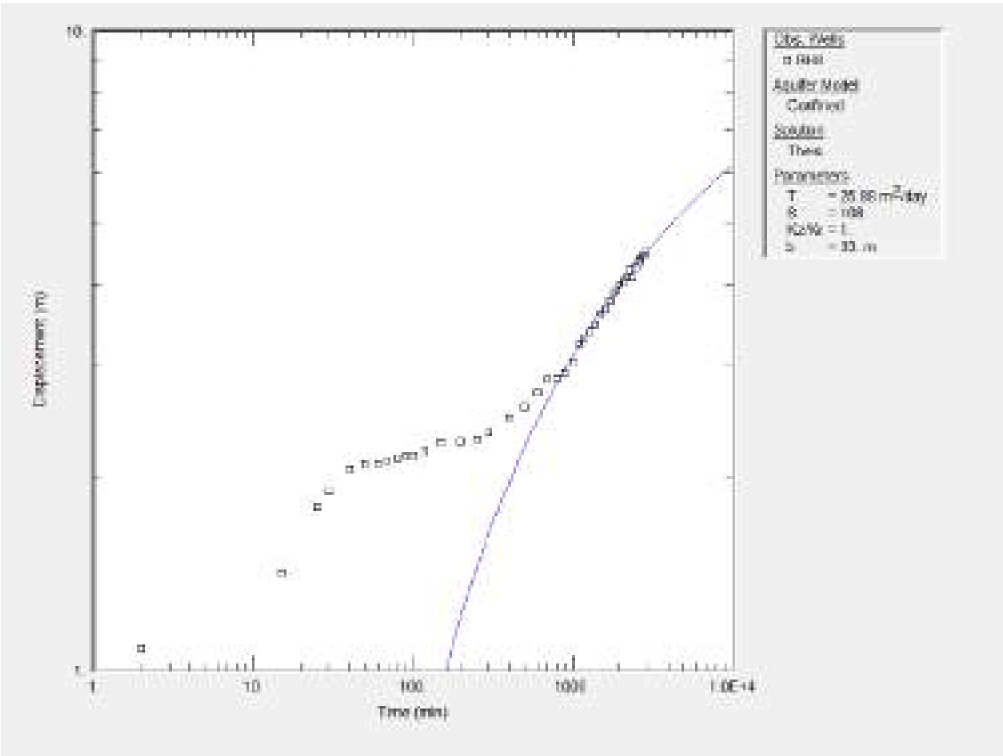

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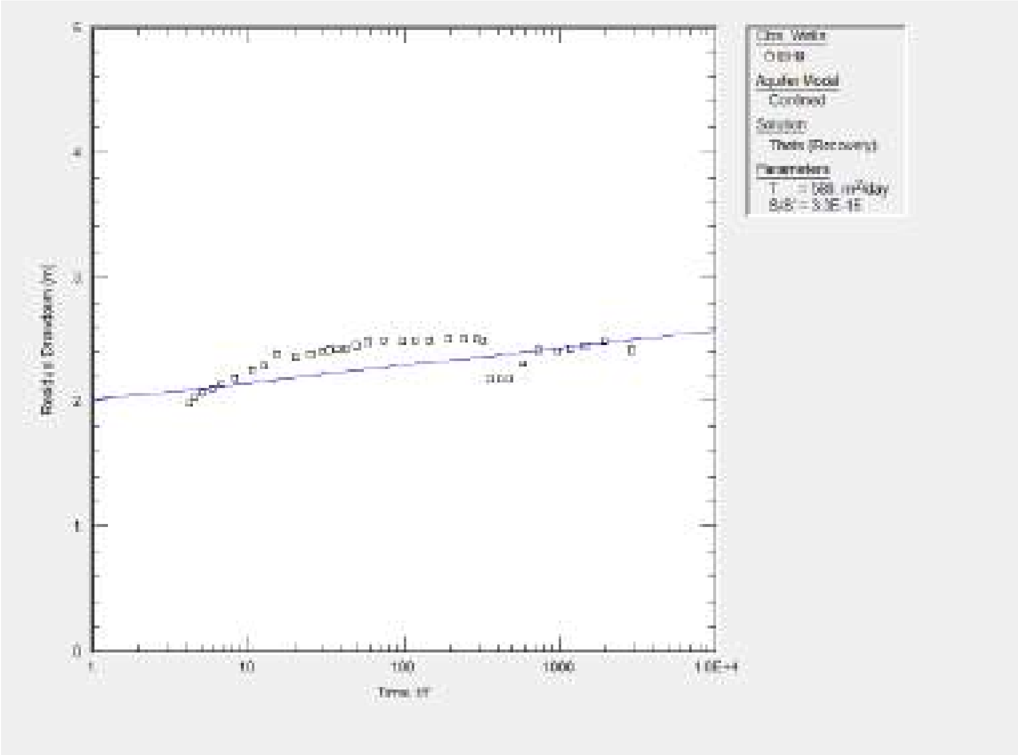

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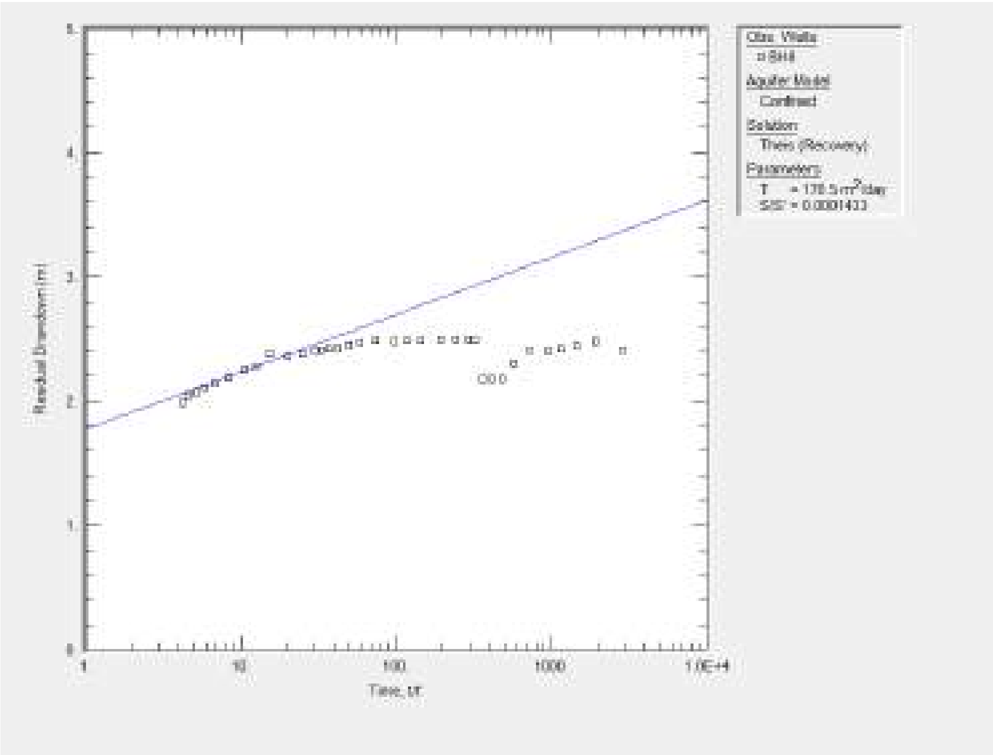

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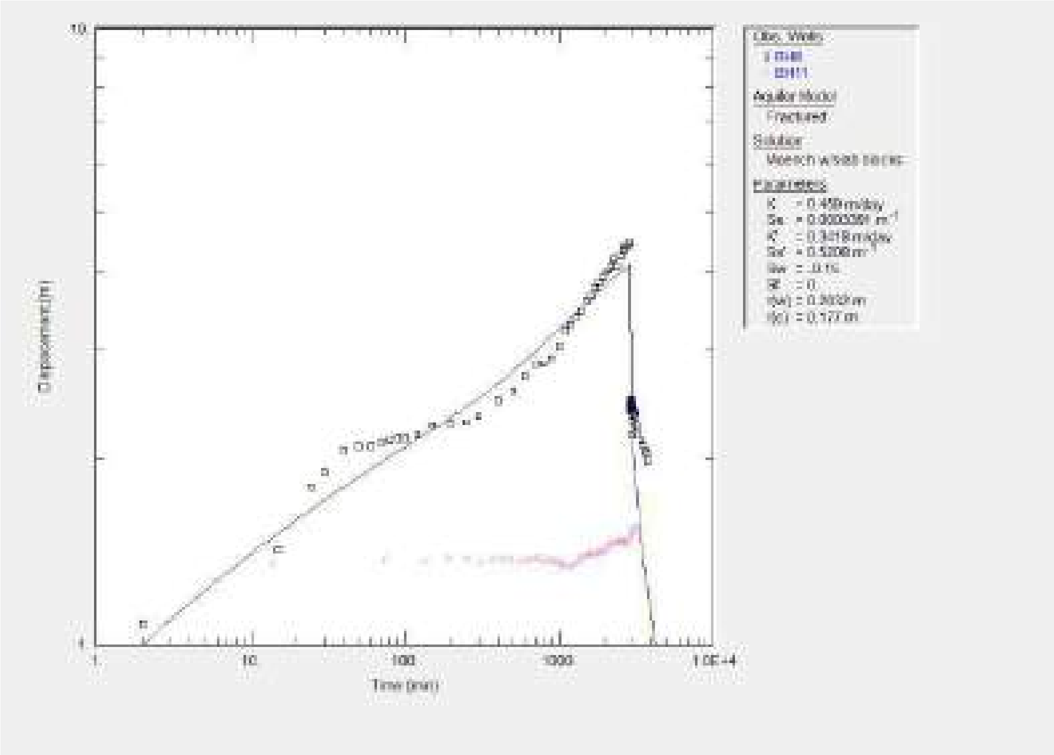

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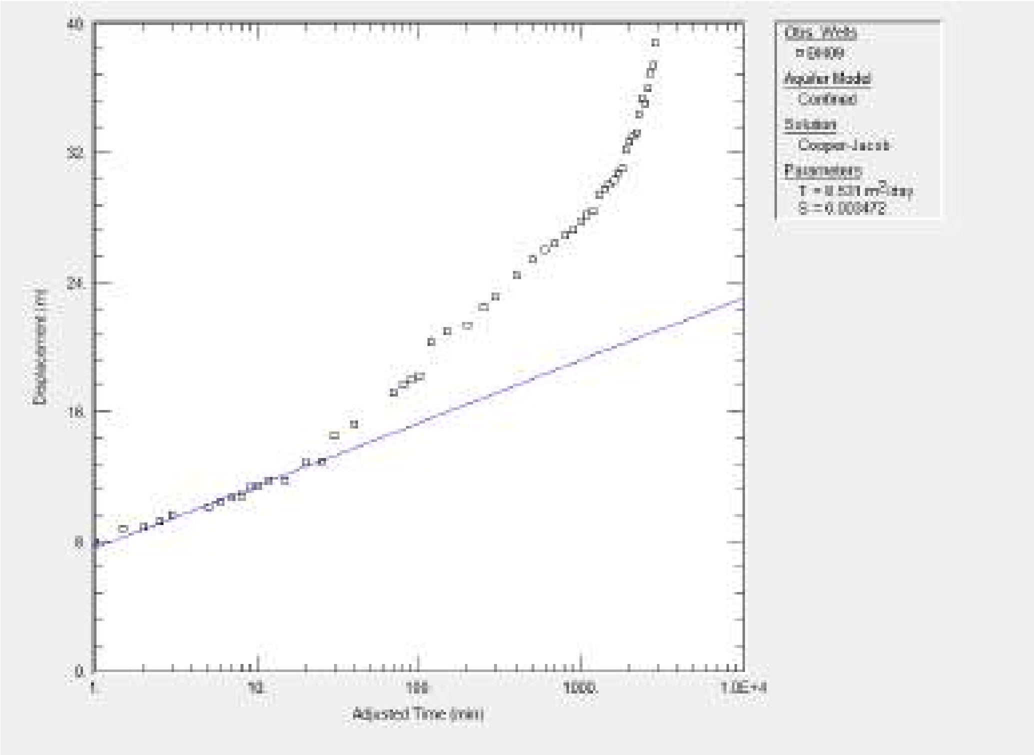

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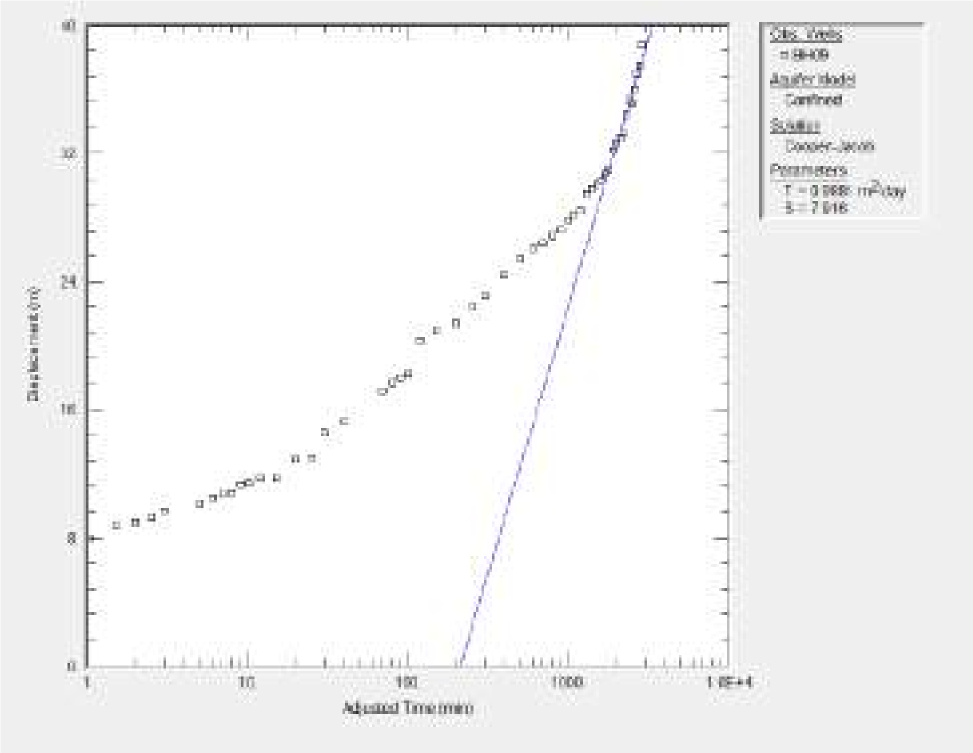

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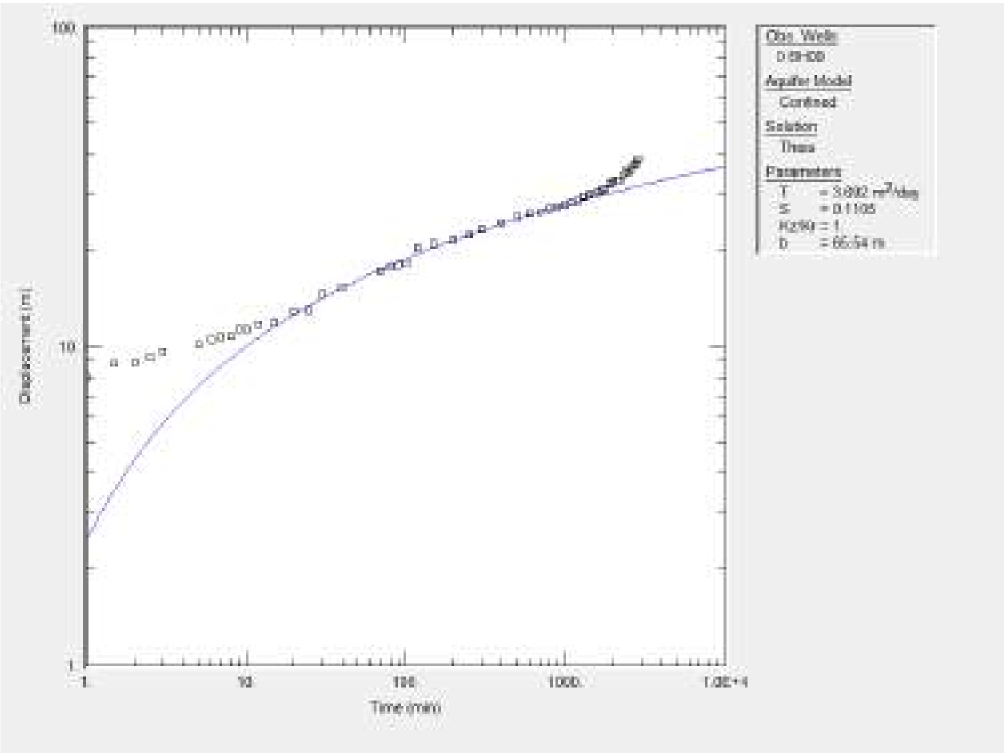

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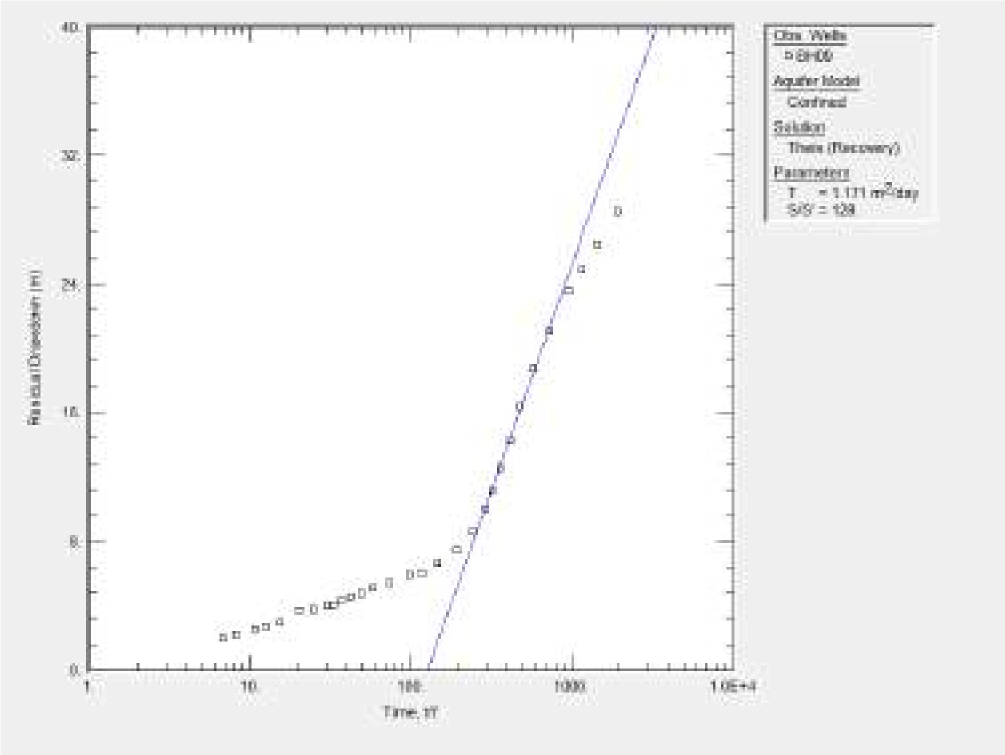

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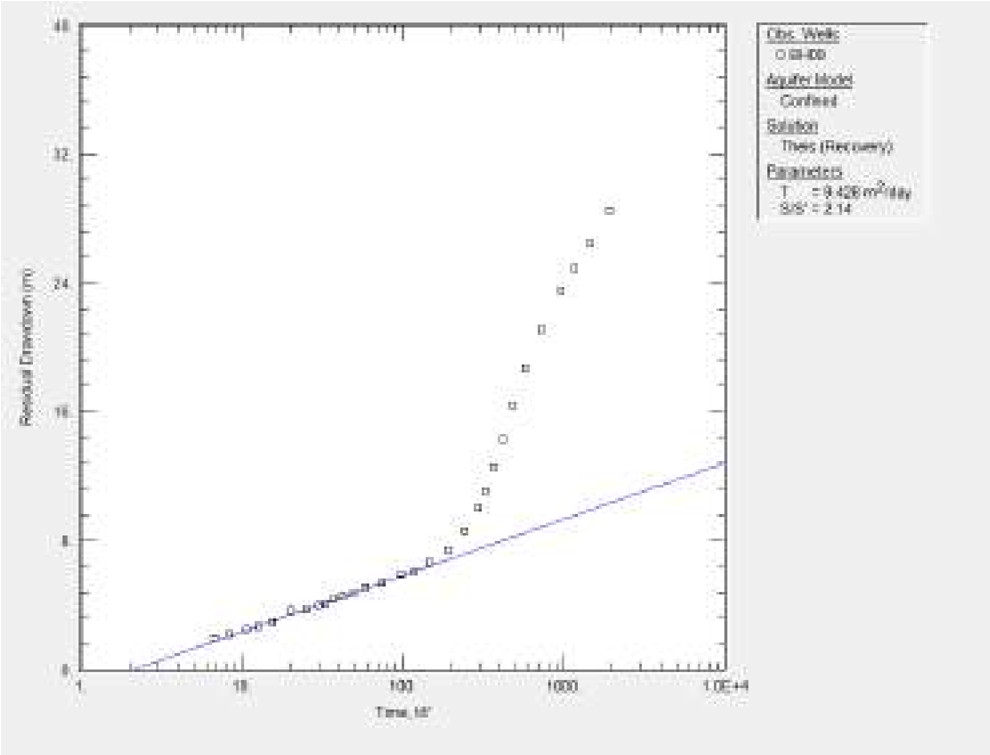

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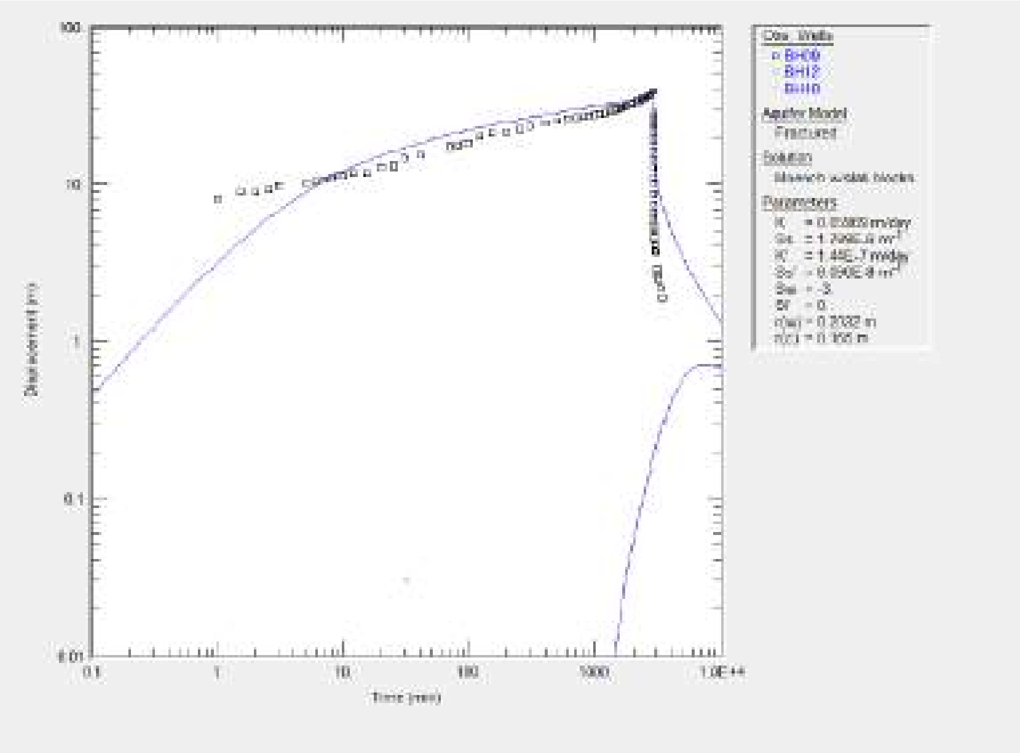

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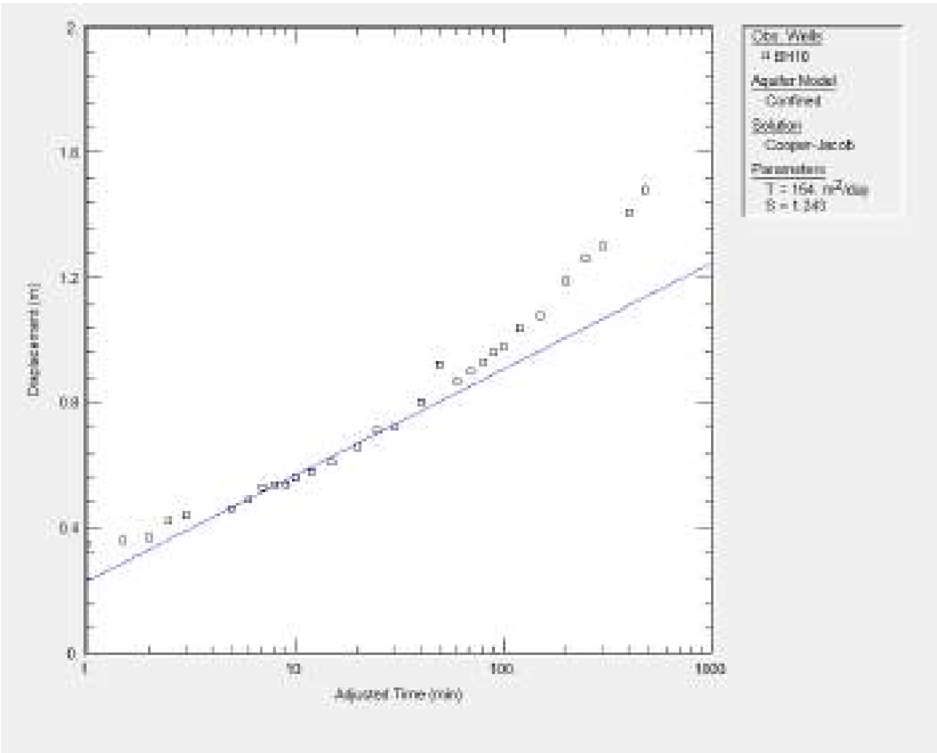

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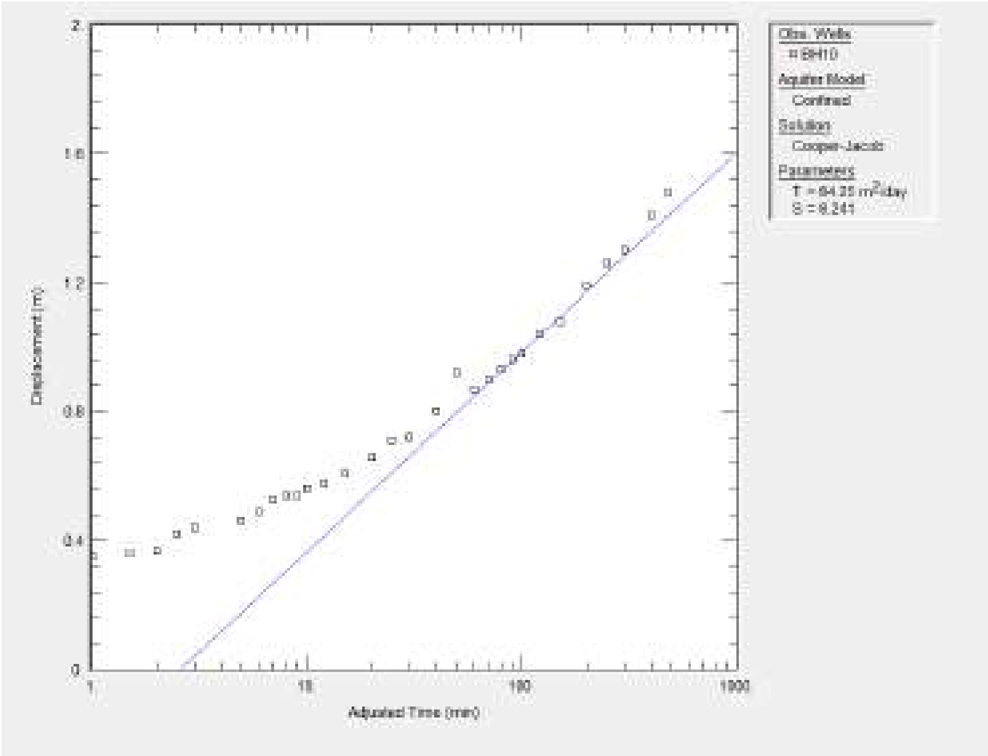

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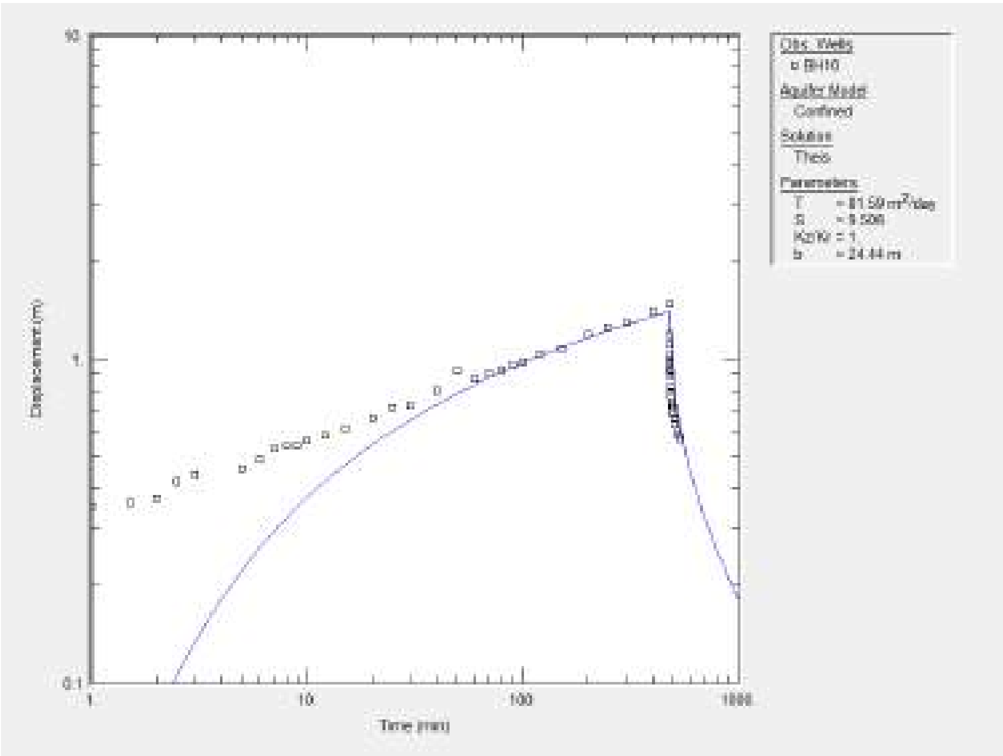

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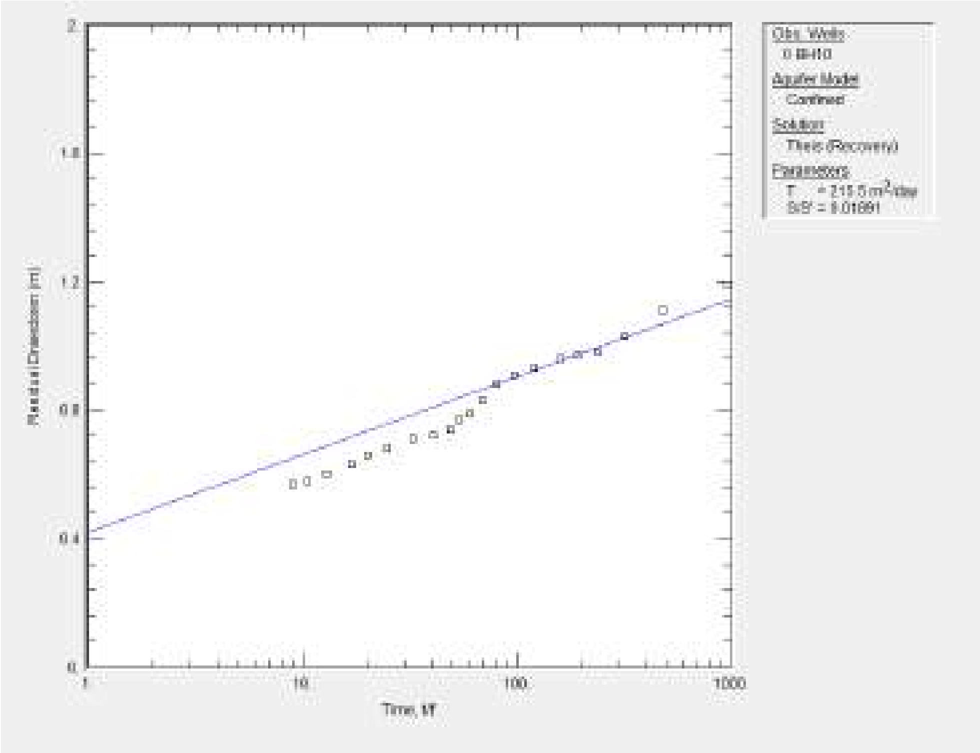

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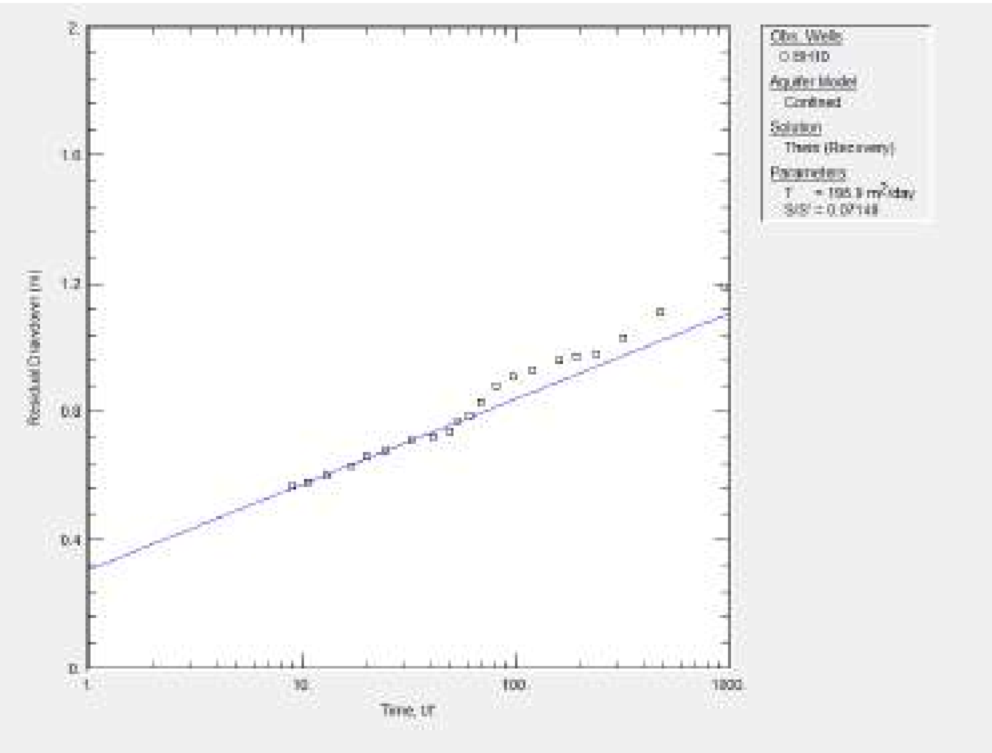

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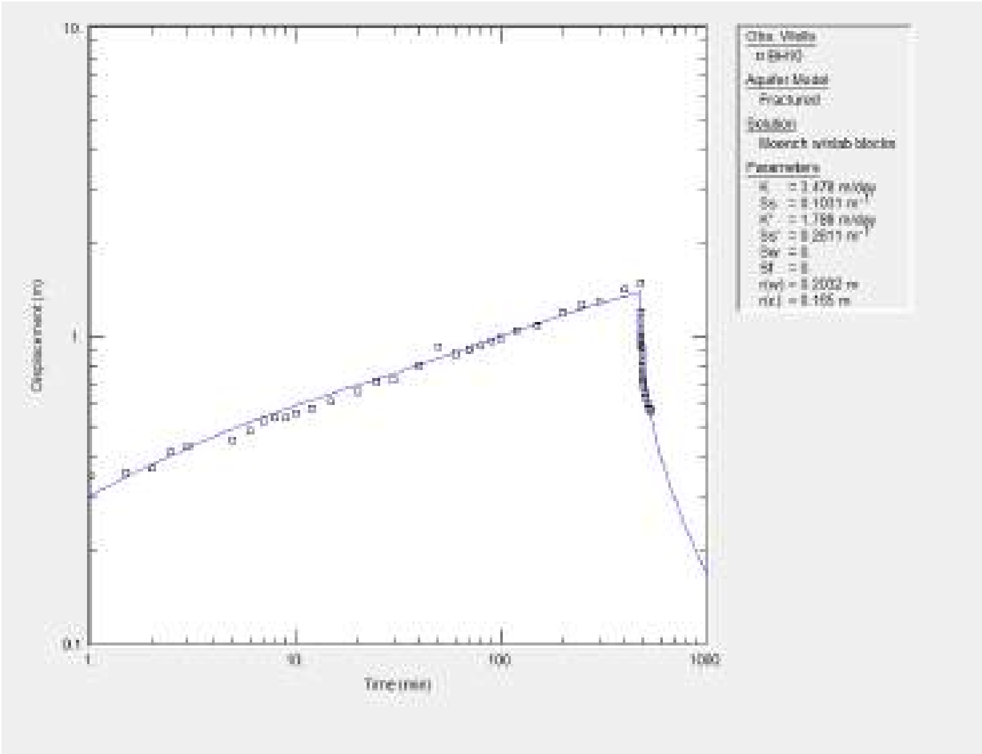

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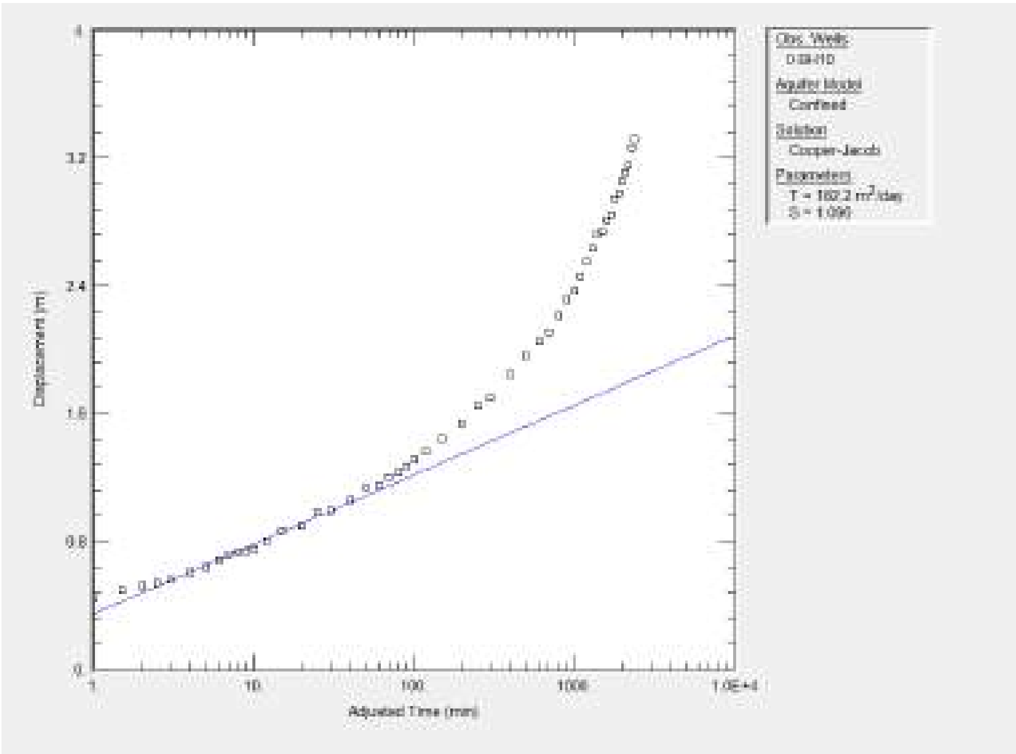

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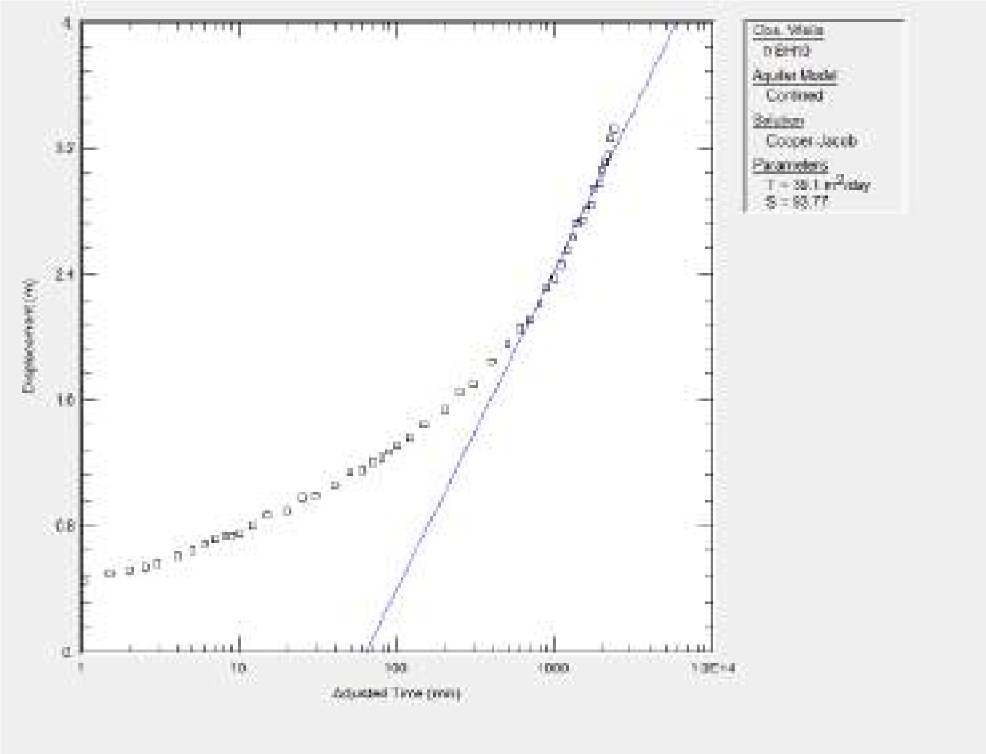

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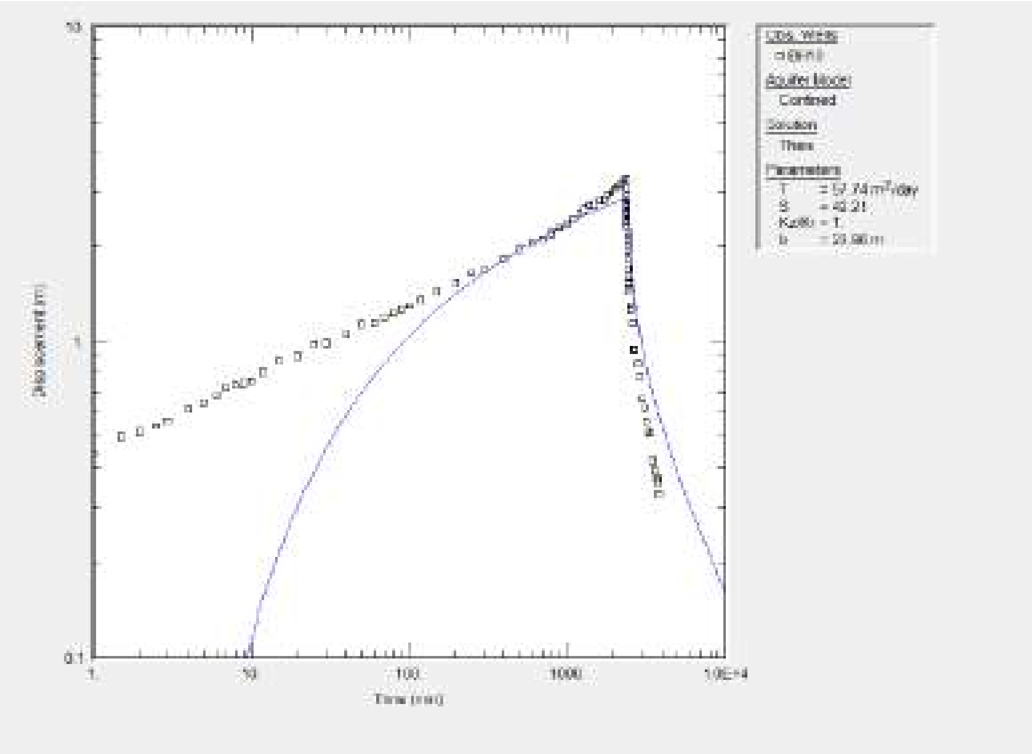

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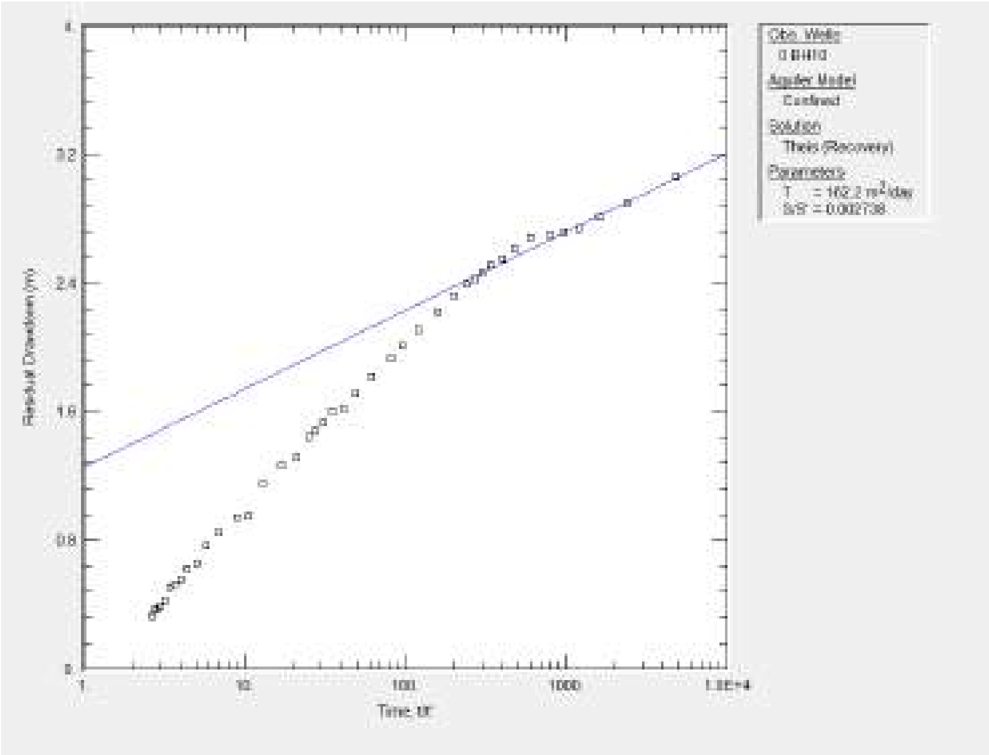

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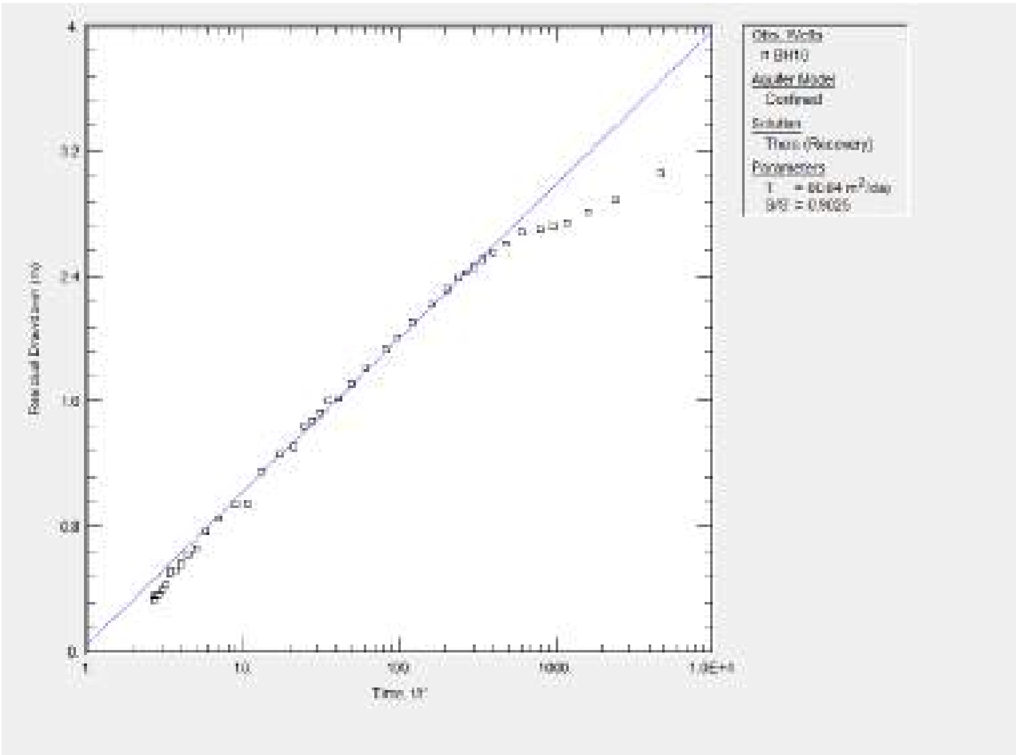

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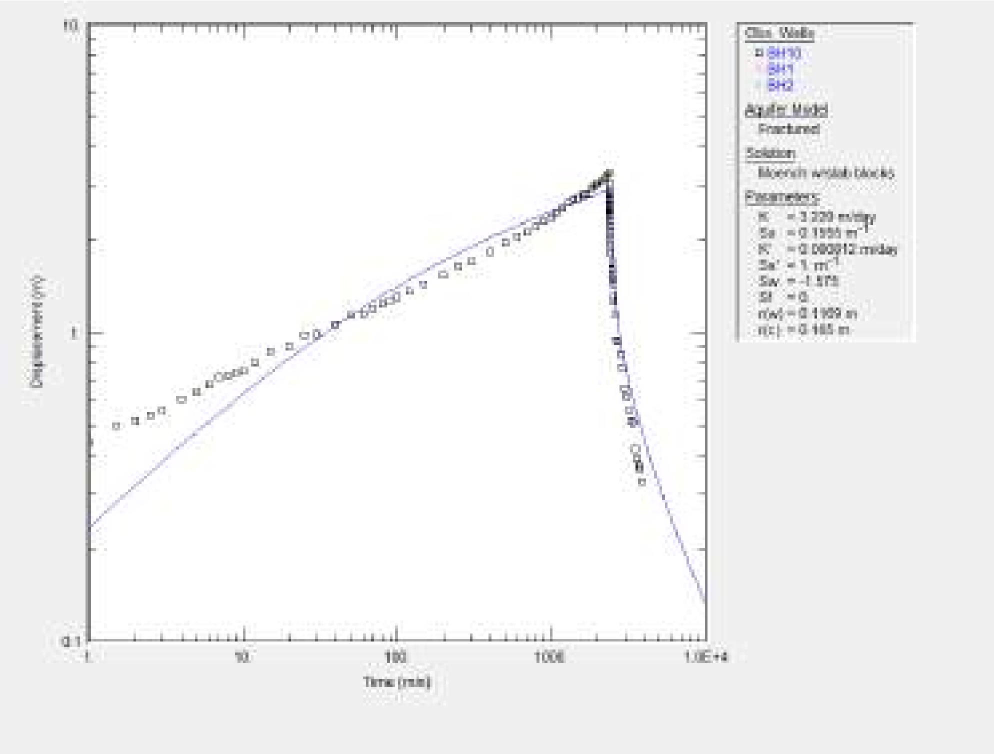

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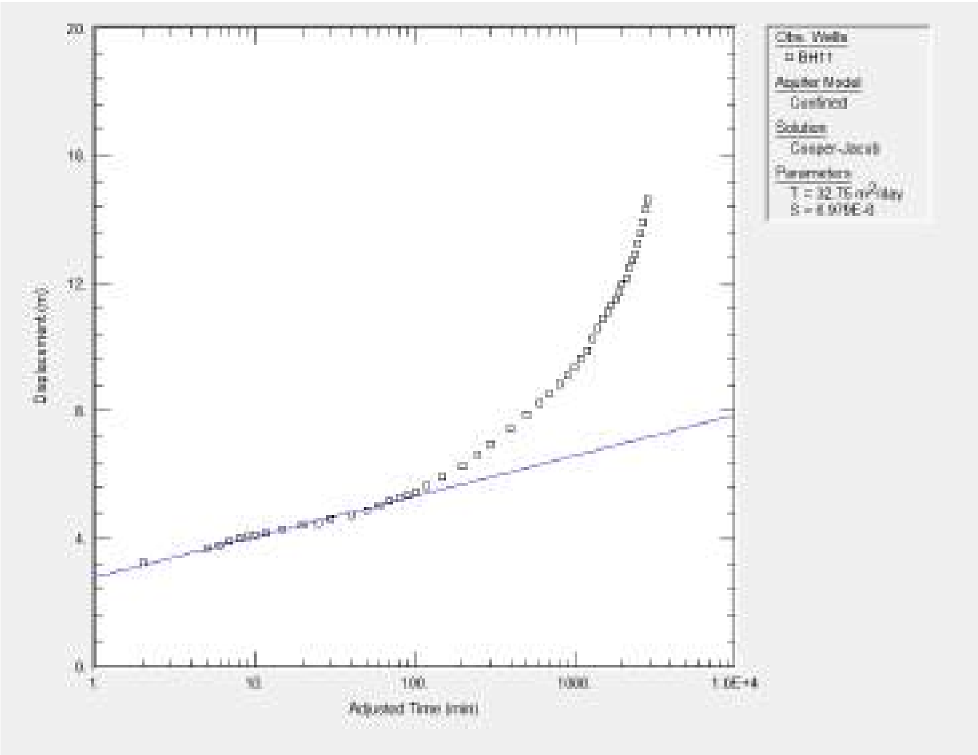

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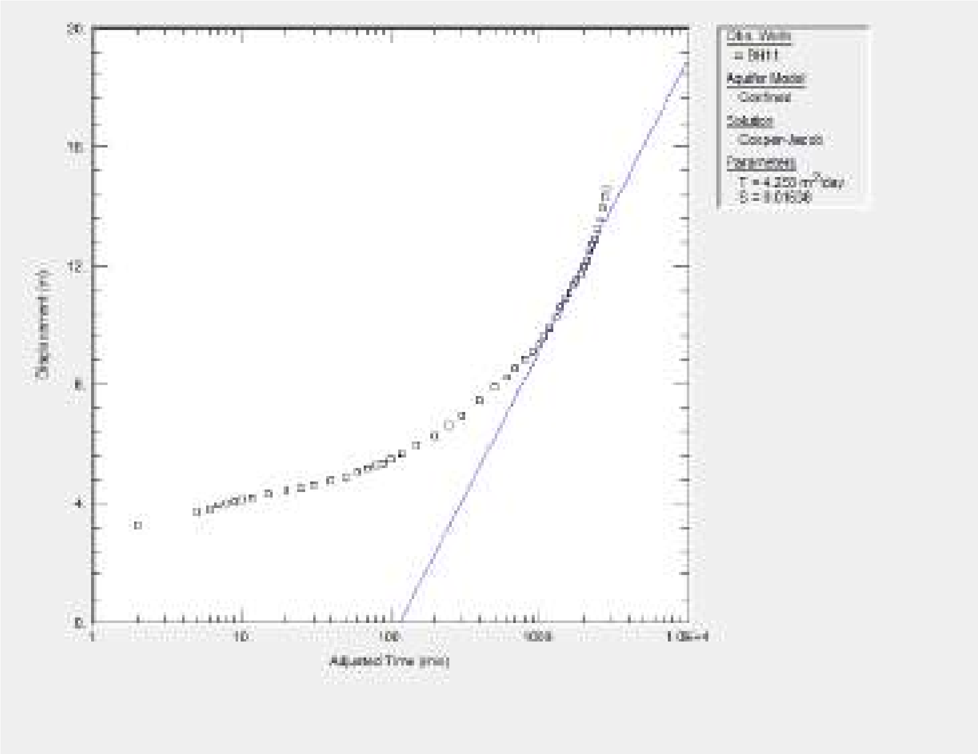

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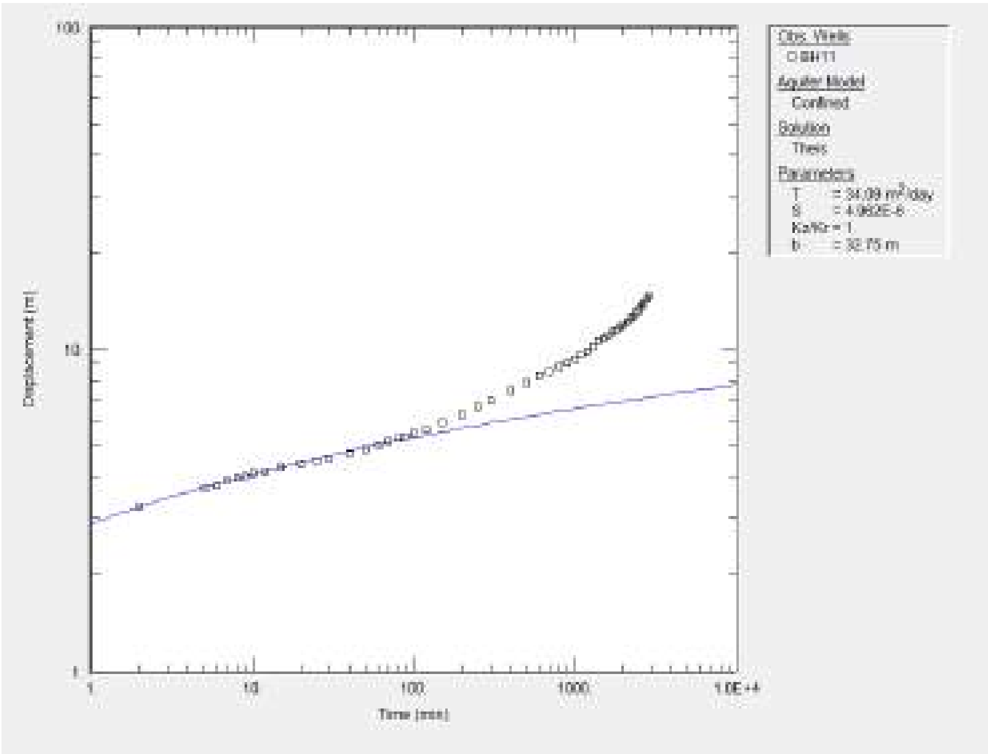

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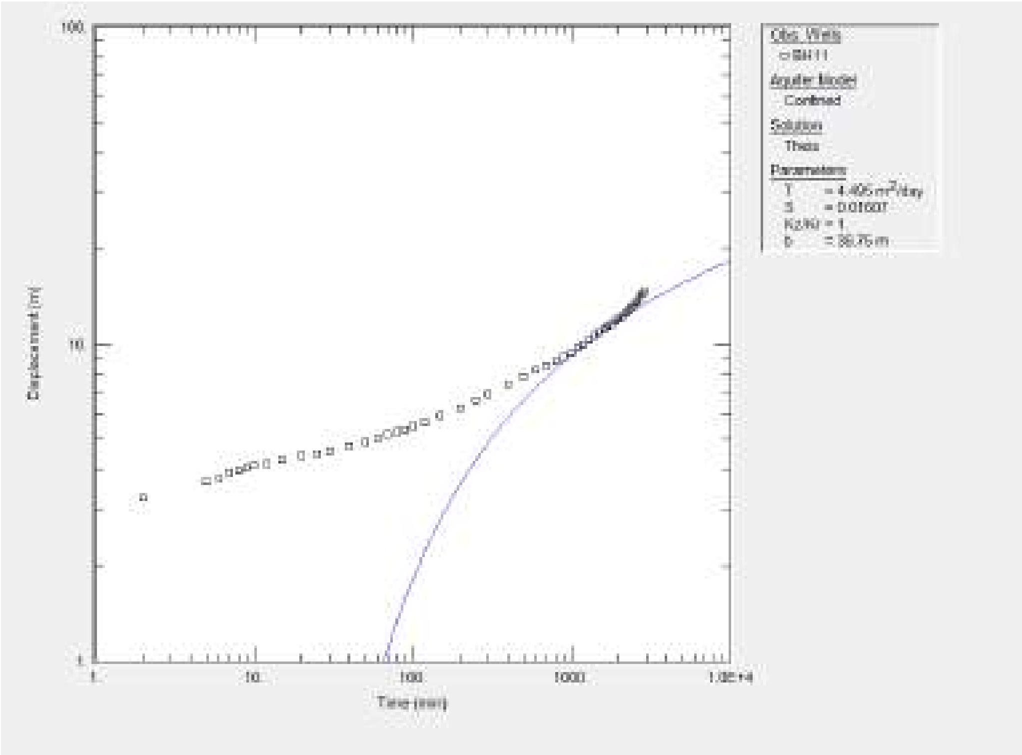

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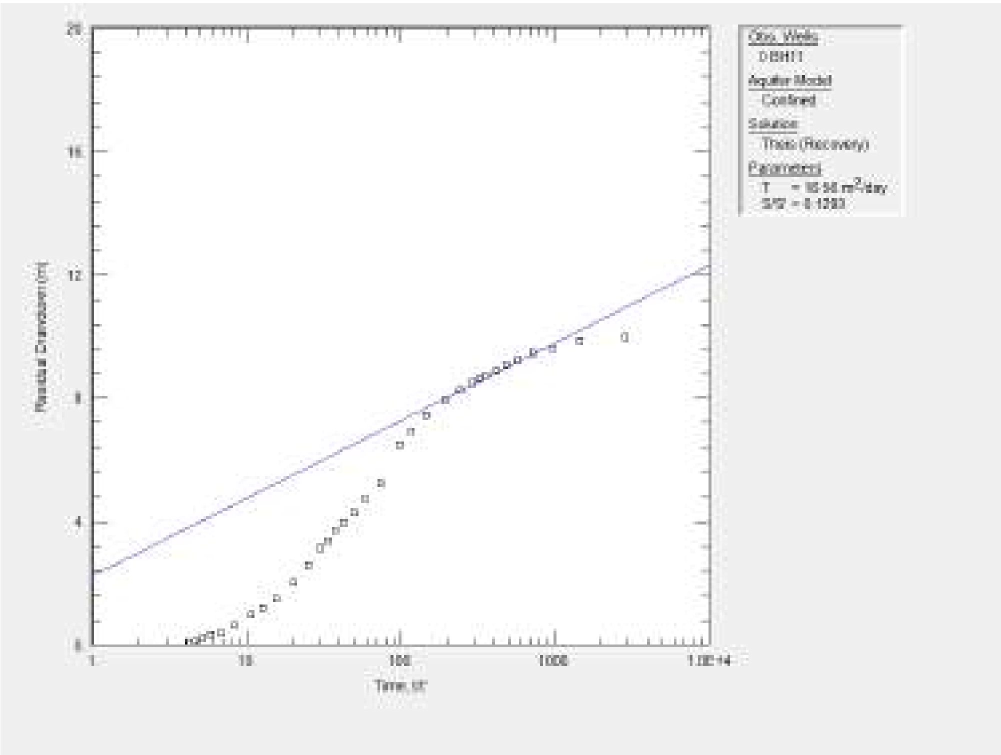

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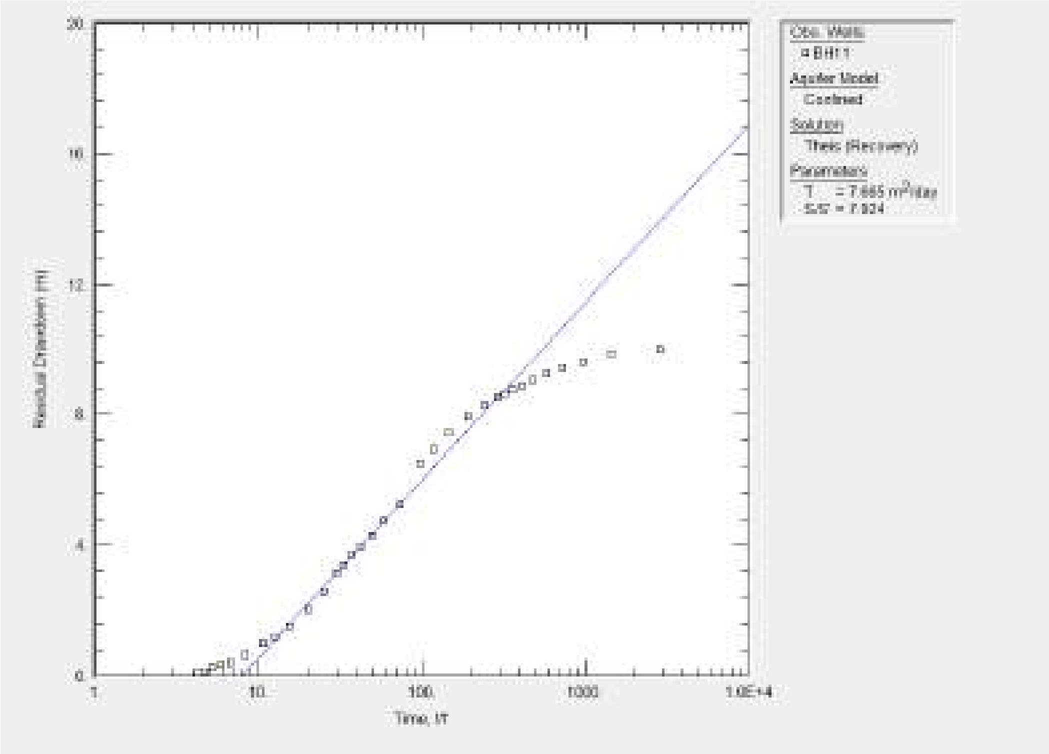

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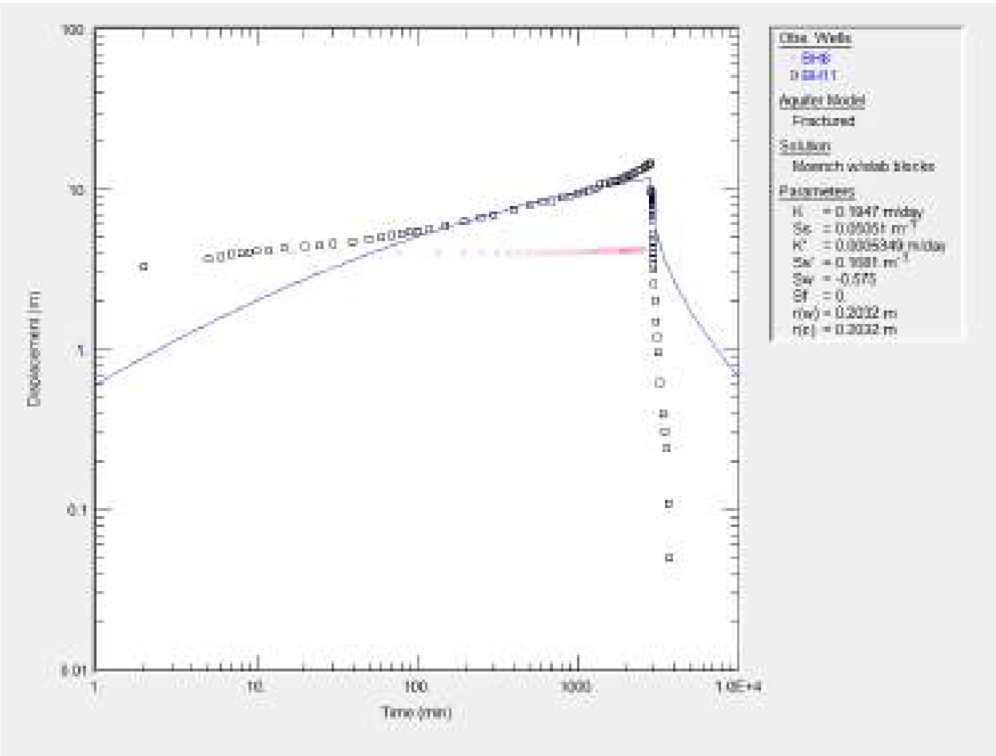

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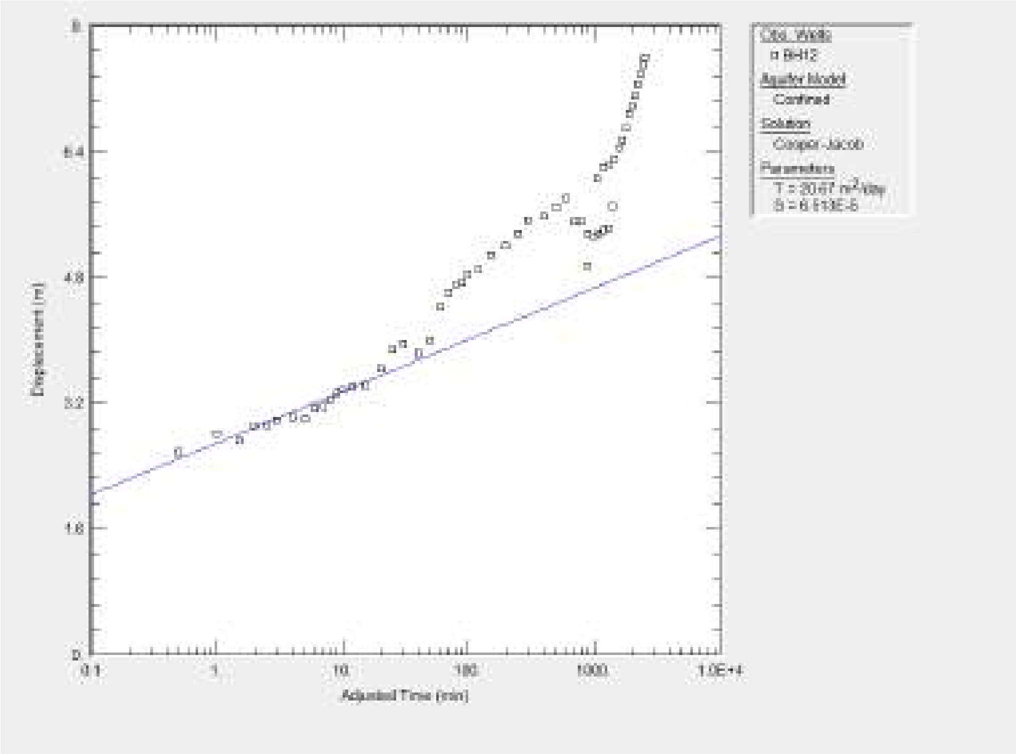

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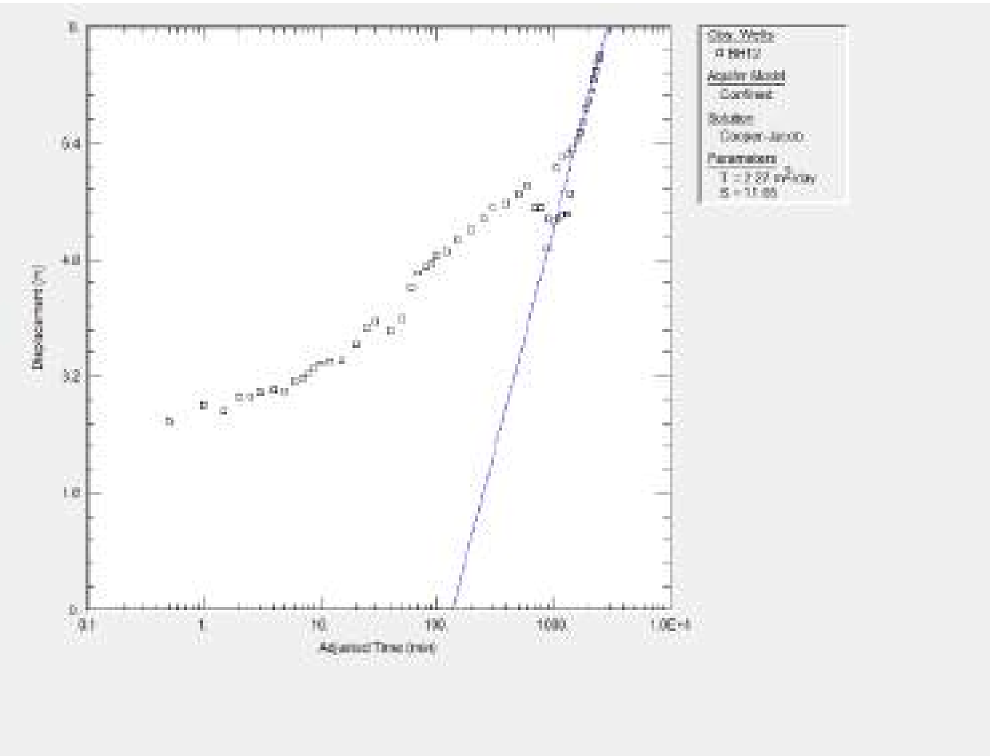

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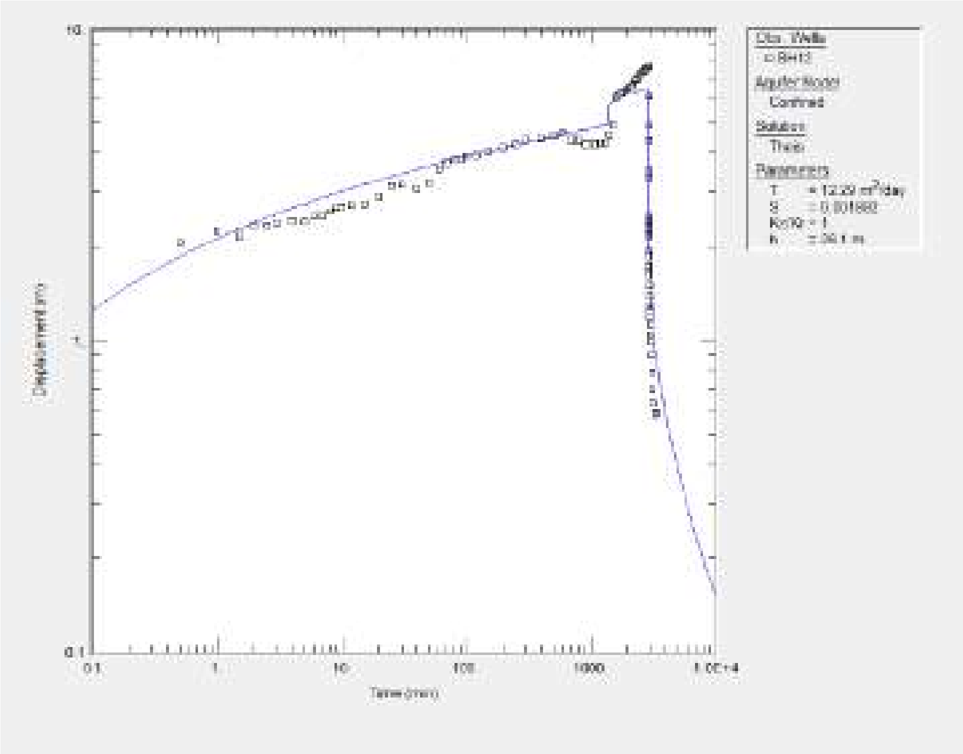

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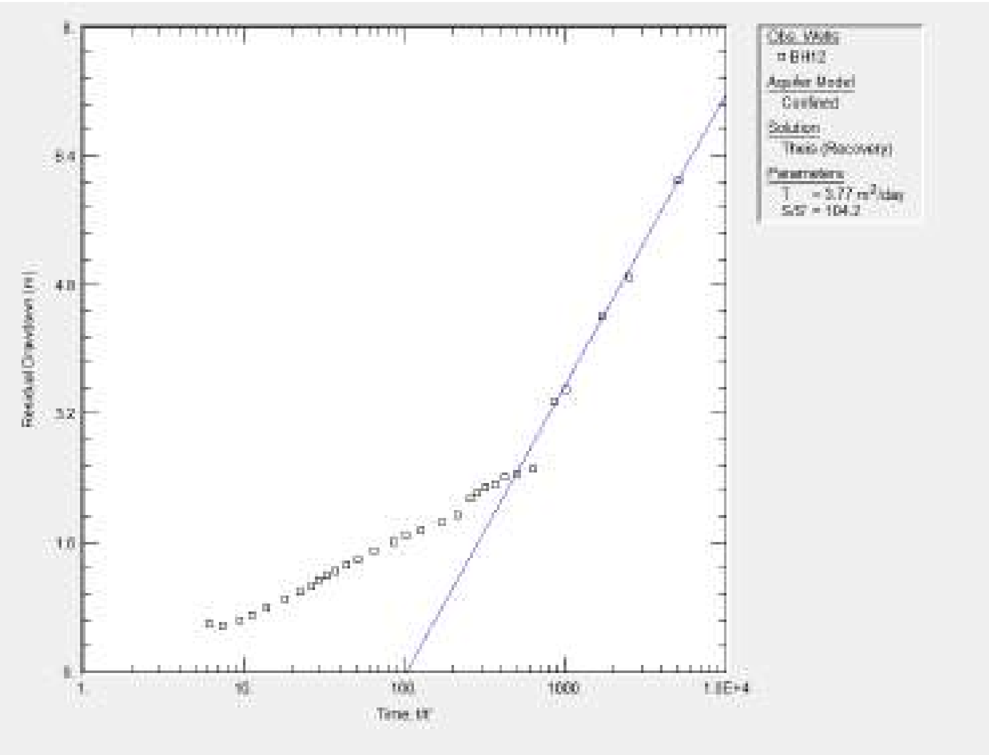

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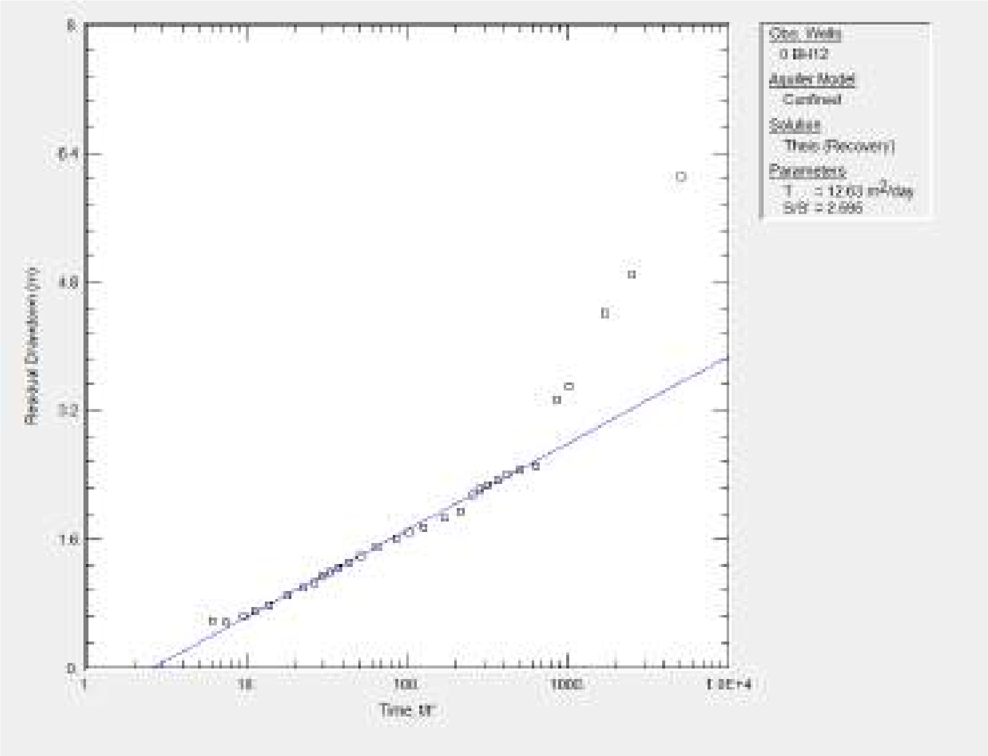

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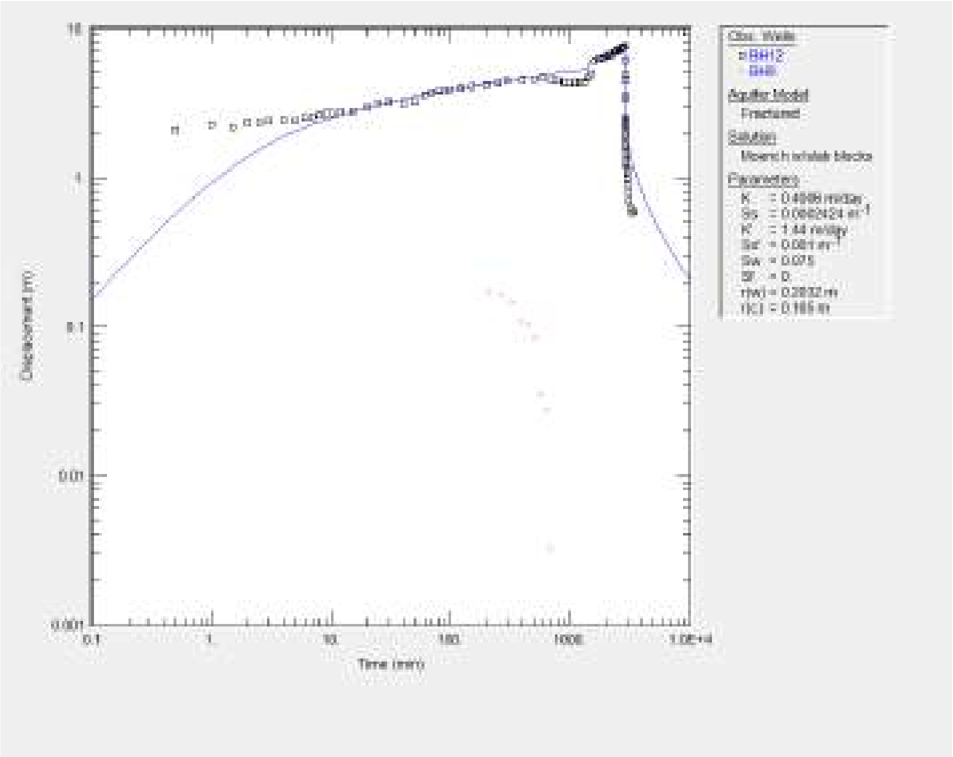


BH12 CDT1 - Moench

Appendix D: Impact Assessment Methodology

Impact Assessment Methodology

The impact assessment methodology that will be utilised during the EIA Phase for the Project consists of two phases namely impact identification and impact significance rating.

Impacts and risks have been identified based on a description of the activities to be undertaken. Once impacts have been identified, a numerical environmental significance rating process will be undertaken that utilises the probability of an event occurring and the severity of the impact as factors to determine the significance of a particular environmental impact.

The severity of an impact is determined by taking the spatial extent, the duration and the severity of the impacts into consideration. The probability of an impact is then determined by the frequency at which the activity takes place or is likely to take place and by how often the type of impact in question has taken place in similar circumstances.

Following the identification and significance ratings of potential impacts, mitigation and management measures were incorporated into the EMP.

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts

The matrix calculates the rating out of 147, whereby intensity, extent, duration and probability are each rated out of seven as indicated in Table B. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation has been applied; post-mitigation is referred to as the residual impact. The significance of an impact is determined and categorised into one of seven categories (The descriptions of the significance ratings are presented in Table C).

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, (i.e., there may already be some mitigation included in the engineering design). If the specialist determines the potential impact is still too high, additional mitigation measures are proposed.

Table A: Impact Assessment Parameter Ratings

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
7	Irreplaceable loss or damage to biological or physical resources or **highly** sensitive environments. Irreplaceable damage to **highly sensitive** cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	<u>International</u> The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or **moderate to highly** sensitive environments. Irreplaceable damage to cultural/social resources of **moderate to highly** sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	<u>National</u> Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
5	Serious loss and/or damage to physical or biological resources or **highly** sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	<u>Province/ Region</u> Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or **moderately** sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	<u>Municipal Area</u> Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
3	Moderate loss and/or damage to biological or physical resources of **low to moderately** sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	**Minor loss and/or effects** to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
1	**Minimal to no loss** and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table B: Probability / Consequence Matrix

Significance

-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Consequence

Table C: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

DIGBY WELLS ENVIRONMENTAL

To:	Jade Greve	Date:	30 June 2022
From:	Digby Wells Environmental	Proj #:	AFT7220
RE:	**Isotope Analysis Results**		

Dear Jade,

This memo provides feedback on the isotope results for the five (5) samples collected at the AfriTin's Tin Mine between 19 and 25 January 2022. The isotope samples were collected to trace links between the water located in the K5 pit with surrounding groundwater locations. The five water samples represent groundwater (BH8, BH10, BH12), pit water (K5) and rainwater (Rain 2), the locations of which are presented in Figure 7.

The Mine is situated in Uis (within the Erongo Region, Namibia), which is approximately 200 km north of Swakopmund. The project area is classified as a hot desert climate (BWh) based on the Köppen-Geiger classification system. The BWh classification characterises areas where evaporation and transpiration exceed precipitation with hot to exceptionally hot (over 40°C) periods of the year. The annual rainfall for the project area ranges between ~2 - 592 mm, with an average of 88 mm per year (National Centers for Environmental Prediction, 2022) (Environmental Compliance Consultancy, 2021). Chloride method estimates from the rainwater sample indicate approximately 0.7% of rainfall contributes to recharge of the groundwater aquifer.

Stable isotopes of oxygen (^{18}O) and hydrogen (^{2}H) can be used as environmental tracers. The composition of stable isotopes in natural waters can change based on physical, chemical, and biological processes that occur within the hydrological cycle as a result of isotope fractionation.

Tritium is a radioactive isotope of hydrogen which has been applied in age determinations of groundwater.

1. Methodology

Two samples were collected from each site, 1 x 1 l sample for the tritium analysis and 1 x 40 ml sample for the stable hydrogen ($\delta^{2}H$) and oxygen ($\delta^{18}O$) analysis. No additives or preservatives were added to the samples. The samples were submitted to Ithemba Laboratories in South Africa for Analysis. In addition to the isotope samples, the groundwater and pit water locations were sampled and analysed for the major cation and anions to determine the hydrochemistry characteristics for the site.

Stable isotopes are reported in δ(‰) values with respect to a common international reference system to allow for comparison to other results obtained from different laboratories. The

Digby Wells and Associates (Pty) Ltd
Company Registration: 1999/005985/07
Turnberry Office Park, Digby Wells House. 48 Grosvenor Road, Bryanston,2191
Phone: +27 (0) 11 789 9495
Fax: +27 (0) 11 789 9498
E-mail: info@digbywells.com
Website: www.digbywells.com

Standard Mean Ocean Water (SMOW) reference standard corresponds to a hypothetical water having both oxygen and hydrogen isotopic ratios equal to the mean isotopic ratios of ocean water. The SMOW reference is a theoretical reference and therefore cannot be used to calibrate laboratory measurements. To assist with the intercalibration of laboratories, a water sample was prepared to have an isotopic composition as close to the SNOW theoretical reference. This reference standard is referred to as Vienna-SNOW (V-SMOW). There is a reported difference of 0.02‰ ($\delta^{18}O$) and 0.2‰ ($\delta^{2}H$) in the V-SMOW reference standard compared to the SNOW reference standard (International Atomic Energy Agency, 1981).

The reference standard used in this report to determine the isotopic ratios is the Standard Mean Ocean Water (SMOW).

1.1. Hydrochemistry

The Piper Diagram is particularly useful for identifying groundwater facies and groups samples with a similar water chemistry. The Expanded Durov Diagram improves on the Piper Diagram by displaying important hydrochemical processes, such as ion exchange, simple dissolution and mixing of waters with different qualities.

The STIFF Diagram graphically displays the water quality which creates distinctive signatures for water samples which can be used to show potential links between sources and receptors.

1.2. Isotope Interpretation

Stable isotopes can be used to determine the origin of groundwaters based on their abundance and variations, which can be subdivided into four categories:

- Meteoric waters are derived directly from precipitation or from fresh surface waters via recharge and the isotope composition of these waters generally matches the composition of the local precipitation.

  In arid areas, groundwater is likely to be more enriched in the heavy isotopes relative to precipitation (International Atomic Energy Agency, 1981). Groundwater aquifers in desert areas are exposed to little irregular precipitation and are therefore less likely to be flushed by recharge so there are increased chances for groundwaters with paleowater characteristics to be present (International Atomic Energy Agency, 1981);

- Paleowater represents meteoric waters which have originated in the distant past especially if there have been climatic changes in the area (International Atomic Energy Agency, 1981);

- Geothermal waters are derived from aquifers which have been exposed to temperatures of more than 80 C which results in a change of isotope composition (International Atomic Energy Agency, 1981); and

- Formation waters represent saline groundwater which are typically located at great depths in sedimentary aquifers (International Atomic Energy Agency, 1981).

1.2.1. Meteoric Waters

A relationship between the stable isotopic ratios of δ^2H and $\delta^{18}O$ in meteoric waters was described in 1961 and defined the Global Meteoric Water Line (GMWL) (Craig, 1961). The GMWL is defined as:

$$\delta 2H = 8 \times \delta 18O + 10$$

Since 1961, IAEA in co-operation with the World Meteorological Organization (WMO) have been undertaking a worldwide survey of the heavy oxygen ($\delta^{18}O$) and hydrogen (δ^2H and ^3H) isotopes in precipitation to determine temporal and spatial variations within these stable isotopes. Initial assessments of the isotope database indicated that the distribution of heavy isotopes can be influenced by latitude, altitude, distance to the coast, intensity of precipitation and surface air temperature (International Atomic Energy Agency, 1992).

A Local Meteoric Water Line (LMWL) was calculated using the isotope in precipitation statistics from the Windhoek Station, which is the nearest station to the Uis Tin Mine. The Windhoek Station analysed rainfall samples between January 1961 and December 2001, resulting in 141 $\delta^{18}O$ results, 97 δ^2H results and 122 δ^3H results. The LMWL statistics for this dataset are provided in Table 1 and were used to calculate the LMWL trend lines using the function:

$$y = ax + b$$

Table 1: LMWL Windhoek Statistics (International Atomic Energy Agency, 2022)

Regression Type	a	b	Std Error	R^2	N
LSR[1]	7.14 ± 0.19	7.95 ± 0.91	7.08	0.94	93
RMA[2]	7.36 ± 0.19	8.59 ± 0.91	7.08	0.94	93
PWLSR[3]	7.30 ± 0.17	9.36 ± 1.00	5.67	0.96	87

A later study by Putman et al (2019) assessed variations in Local Meteoric Water Lines (LMWL) compiled using the isotope dataset by the International Atomic Energy Agency (IAEA). From this study seasonal trends (Figure 1) were identified (Putman, Fiorella, Bowen, & Cai, 2019). Arid regions of the Köppen-Geiger classification are categorized as B: hot/dry – hot/humid which have a range in $\delta^{18}O$ of between -9‰ - 9‰ and δ^2H of between -40‰ - 10‰.

[1] LSR – Least Squares Regression Method.
[2] RMA – Reduced Major Axis Regression Method.
[3] PWLSR – Penalised Weighted Least Squares Regression Method.

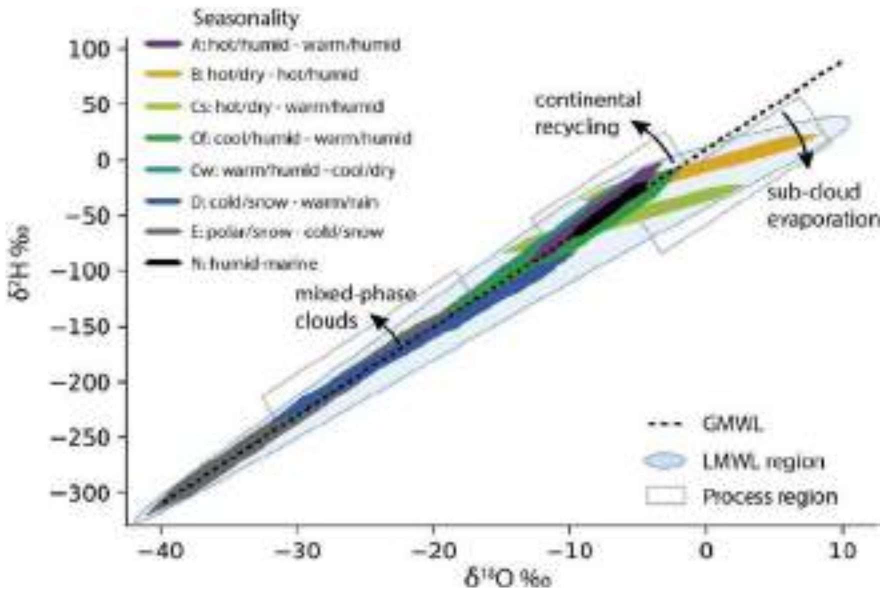


Figure 1: Seasonality of LMWL around the GMWL (Putman, Fiorella, Bowen, & Cai, 2019)

1.2.2. Paleowater

Paleowater is groundwater which originates from water cycles under different environmental conditions to the present day. Paleowater characteristics can follow similar enrichment processes to meteoric water especially if related to evaporitic period or marine transgressions. The dating of dissolved inorganic carbon (DIC) becomes important to identify paleowater and understand the methods of recharge (International Atomic Energy Agency, 1981).

Tritium is the only radioactive isotope of hydrogen with a half-life of 12.43 years. During the 1950's and 1960's large quantities of tritium were introduced into the hydrological cycle because of atmospheric thermonuclear testing and therefore tritium is used as an environmental tracer for water originating from this period (Solomon & Cook, 2000). Waters which are derived exclusively from precipitation before 1953 would have a maximum tritium concentration of 0.1-0.4 TU. Higher tritium values in water indicate that some water has been derived from precipitation after 1953 (Kendall & Doctor, 2003).

2. Results

2.1. Groundwater Levels

The water level in the K5 pit (774 mamsl) is currently lower than the surrounding groundwater levels measured in the water supply boreholes (which ranges between 778 – 800 mamsl. Groundwater will therefore flow towards the pit along fractures and groundwater flow paths (Figure 2).

2.2. Hydrochemistry

Water Quality samples were taken from the groundwater boreholes (BH8, BH10 and BH12) as well as the K5 pit. There were a total of five (5) groundwater samples collected per borehole as part of the hydrogeological water supply assessment. One sample was collected from the K5 for comparison.

Based on the Piper (Figure 3) and Expanded Durov (Figure 4) Diagrams the groundwater samples for BH8, BH10 and BH12 indicate a sodium-chloride water type which typically indicates groundwater with a long residence time or stagnant (slow moving) groundwater with little to no recharge. The K5 pit sample has a similar hydrochemistry to the groundwater samples as displayed on the Piper and Expanded Durov Diagrams.

The STIFF Diagrams (Figure 5) for the groundwater samples display a similar signature to each other and confirms the dominance of the sodium and chloride ions. The K5 pit water sample has a similar signature to the groundwater samples but with higher salt concentrations because of evaporation.

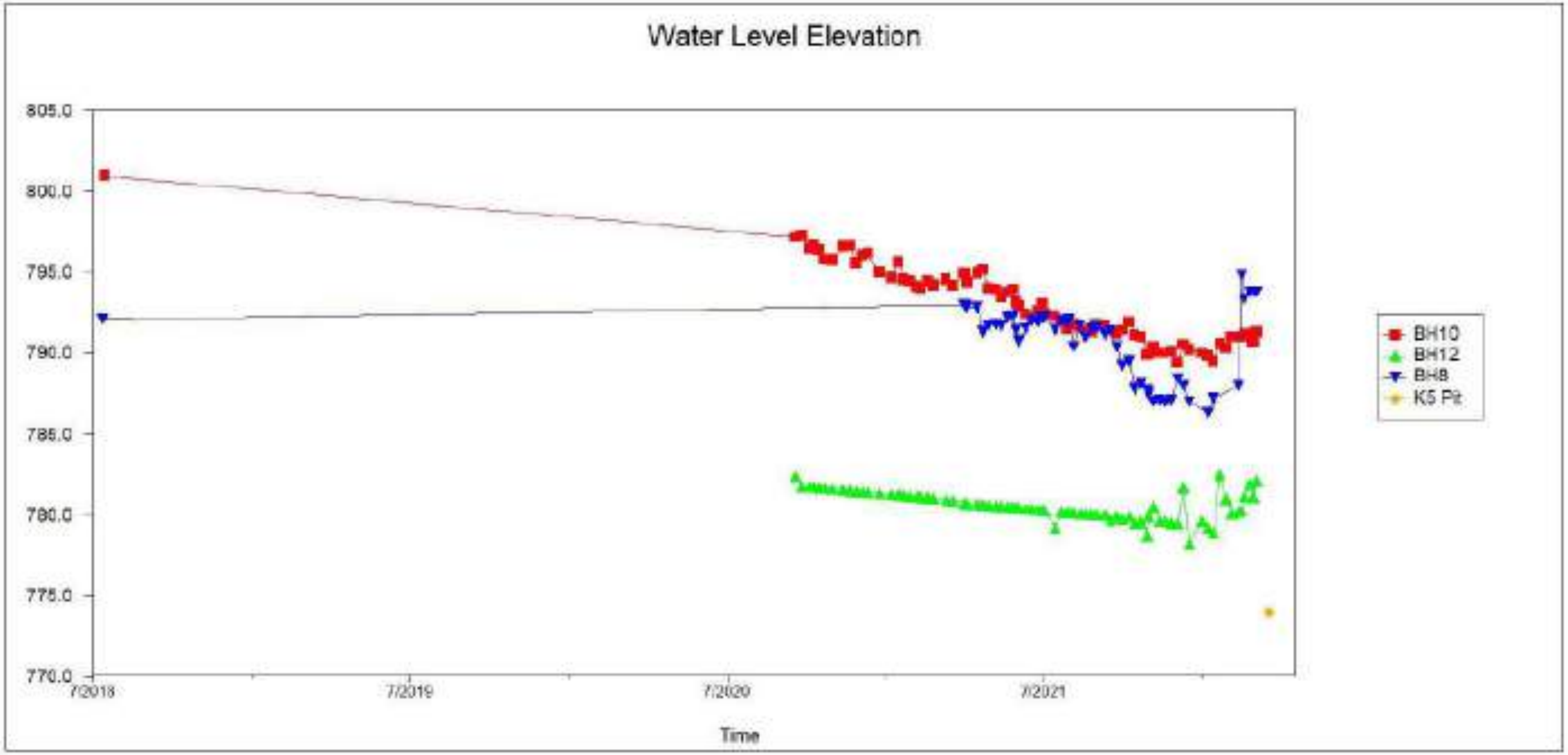


Figure 2: Groundwater Elevations

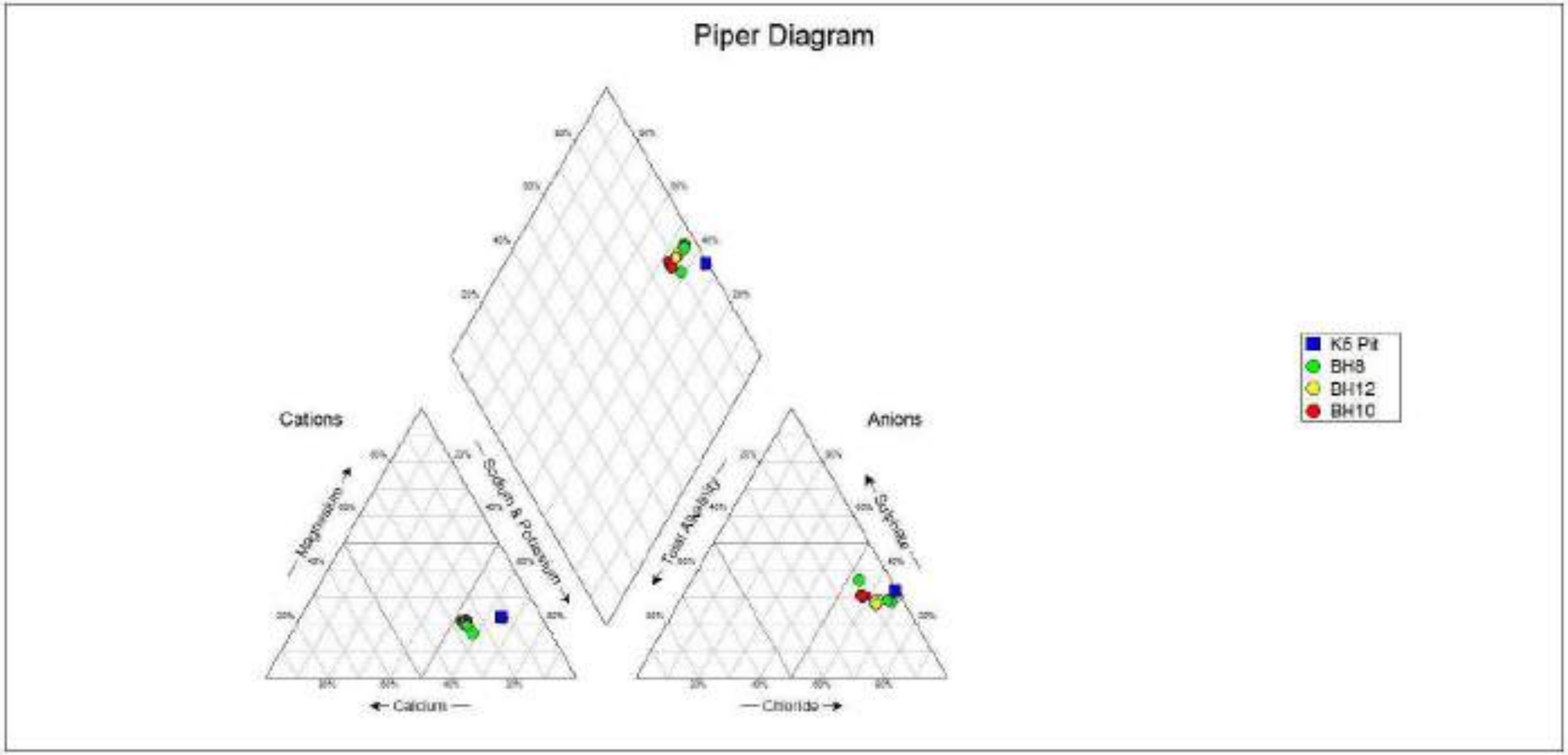


Figure 3: Piper Diagram

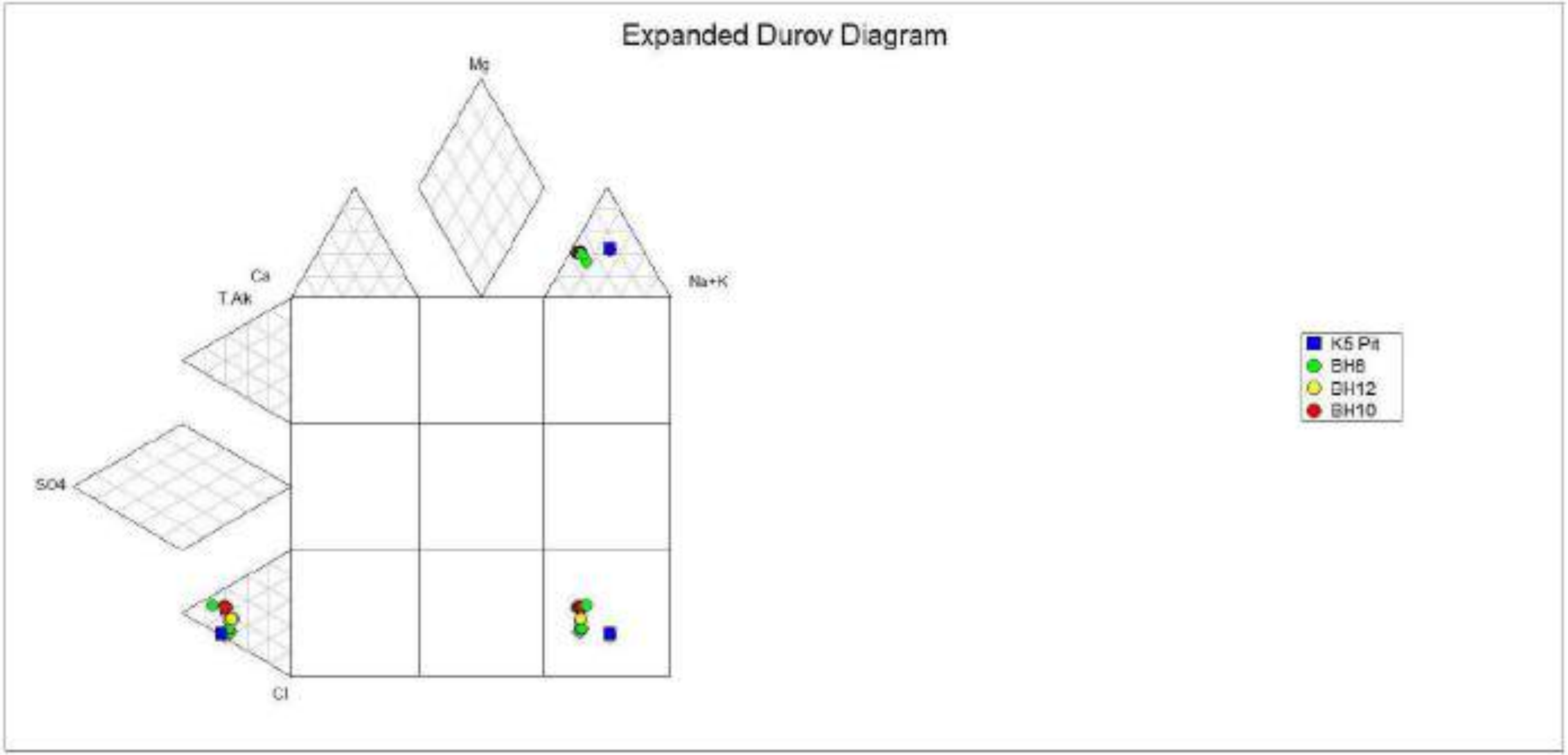


Figure 4: Expanded Durov

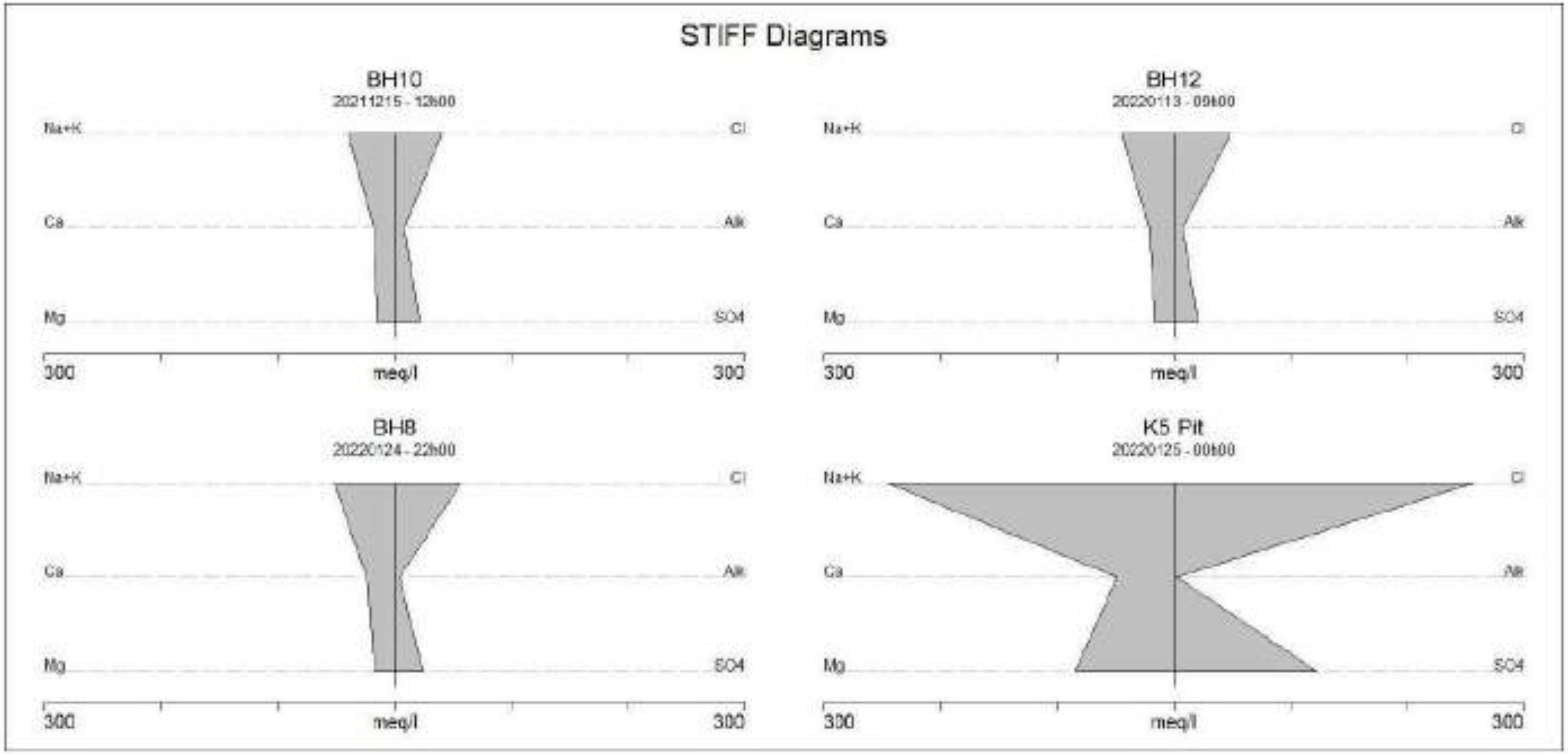


Figure 5: STIFF Diagram

2.3. Stable Isotopes

The Isotope results are provided in Table 2. A sample showing a negative δ value is depleted in heavier isotopes, and a sample with a positive δ value is enriched in heavier isotopes in respect to the SMOW. A more/ less positive versus more/less negative is used to describe the difference between two isotope values.

Table 2: Isotope Results

Sample ID	Sample Date	δ^2H ‰	TU	$\delta^{18}O$ ‰
K5	25/01/2022	+31.9	1.4 ± 0.3	+9.25
BH8	25/01/2022	-35.8	1.2 ± 0.3	-4.90
BH10	25/01/2022	-42.5	0.6 ± 0.3	-5.89
BH12	25/01/2022	-38.6	1.2 ± 0.3	-5.31
Rain 2	19/01/2022	-55.5	3.3 ± 0.4	-8.76

The rainwater sample has isotopic ratios of $\delta^{18}O$ and δ^2H as -8.8‰ and -55.5‰ respectively. This sample plots near the lower range of $\delta^{18}O$ and δ^2H for arid climates and is more positive in the δ^2H isotope and more negative in the $\delta^{18}O$ isotope as compared to the GMWL (Figure 6). The LMWL calculated using the LSR, RMA and PWLSR statistics (International Atomic Energy Agency, 2022) are also provided on Figure 6 and show a better fit to the collected rainwater sample.

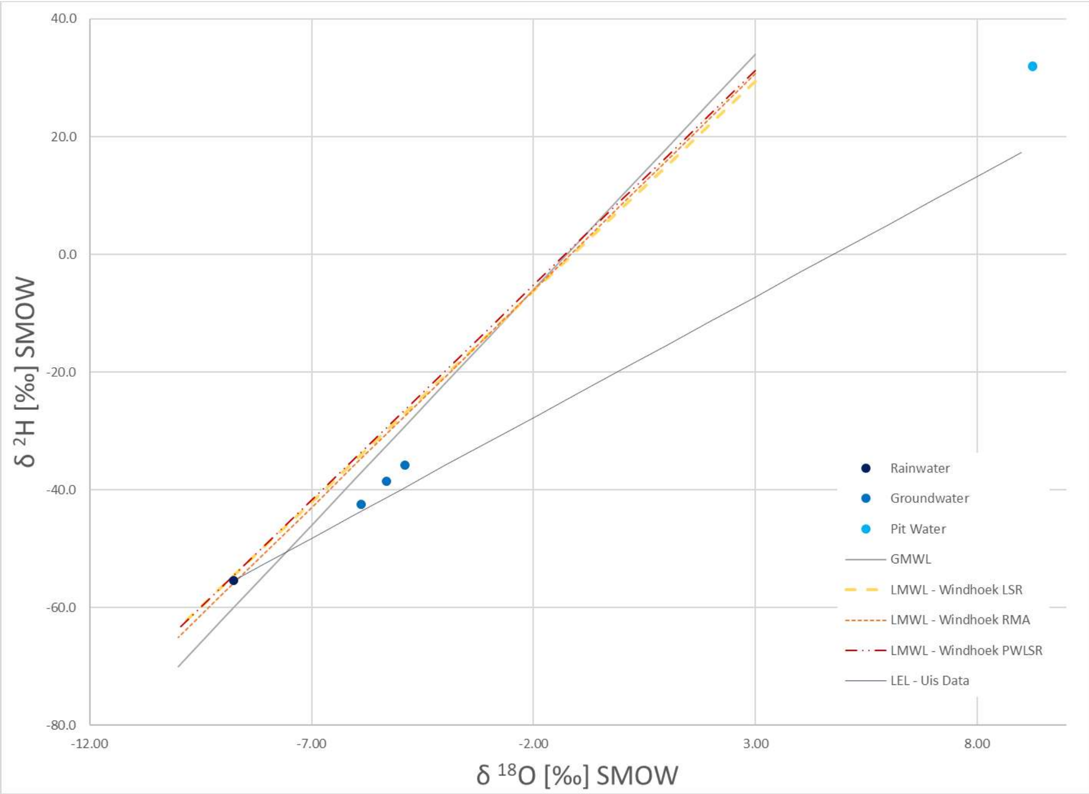


Figure 6: Isotope Results Compared to Meteoric Data

The Pit Water sample (K5) has the highest values of $\delta^{18}O$ and $\delta^{2}H$ compared to the rainwater and groundwater samples. Lakes and surface water bodies which lose water by evaporation are characterised by an enrichment in the heavy isotopes (International Atomic Energy Agency, 1981) because of the isotopic fractionation which occurs between the liquid and gaseous phases of water during the evaporation process. The enrichment of the heavy isotopes occurs along Local Evaporation Lines (LEL) which deviate from the meteoric water line with lower slopes. Based on the rain and pit water samples the slope of the evaporation line calculates to 4.1 using the following function:

$$S = \frac{[h(\delta a - \delta w) + \epsilon]2H}{[h(\delta a - \delta w) + \epsilon]18O}$$ [4]

The dominant isotopic fraction in evaporation is kinetic fractionation, which is an irreversible process, where the product of the process is continuously removed. In an evaporation process the effect is not only dependent on temperature but also the relative humidity (h) of the atmosphere. The effect of humidity is important for the interpretation of the LEL slope as the smaller the humidity is the higher the change in δ^{18} O and δ^{2} H values will be. The calculated

[4] Where h represents a humidity of 43% (World Weather Online, 2022);
Δa represents the respective isotope in atmosphere vapor (assumed to be represented by the precipitation isotopes);
Δw represents the respective isotope in surface water; and
ϵ (Total isotope fractionaction) calculated using the hydrocalculator (Skrzypek, et al., 2015).

LEL for the Uis data is indicative as the calculation based on average temperature and humidity values for Uis in January[5].

The three groundwater samples (BH8, BH10 and BH12) indicate similar results for the stable isotopes with a range in $\delta^{18}O$ of between -5.9‰ – -4.9‰ and a range in $\delta^{2}H$ of between -42.5‰ – -35.8‰. The groundwater samples are more positive in $\delta^{18}O$ and $\delta^{2}H$ compared to the rainwater sample and plot below the GMWL and LMWL and within the arid climate range of the seasonality trend.

The groundwater samples can be representative of meteoric water which has been enriched in the heavier isotopes because of evaporation. The lower slopes of evaporation lines for the groundwater samples are often linked to diffusive evaporation from soil water and fractionation occurring before percolation takes place.

There is the potential for paleowater or mixing of paleowater to be present but additional $^{13}C/^{14}C$ isotopic assessments would be required to determine this and would likely be limited to ages less than 20 000 - 25 000 years (International Atomic Energy Agency, 1981). The tritium results will provide more information as to the recent age of the water samples.

2.4. Tritium

The tritium results are provided in Table 2. The rain sample indicates a tritium value of 3.3 ± 0.4 TU which is in the range expected for rainfall with 1 TU being indicative of high precipitation in oceanic regions and 10 TU representing arid inland areas (Phillips & Castro, 2014).

The K5 pit sample has a similar tritium value (1.4 ± 0.3 TU) to BH8 and BH12 (1.2 ± 0.3 TU), all higher than 0.1-0.4 TU, indicating that these waters are recent and have been derived from precipitation after 1953. These sample locations have had a similar exposure to precipitation from the 1950s.

The sample collected from BH10 has a lower tritium value of 0.6 ± 0.3 TU compared to the other samples indicating that the source of water was predominately recharged prior to 1953 (old water) with less recharge post 1950's when compared to BH8 and BH12. This could indicate BH10 is drawing from a deeper fracture system in comparison to BH8 and BH12 even though the main water strike is shallower or that the fracture system is not recharged as easily as the fractures supplying BH8 and BH12.

3. Conclusion

Based on the groundwater levels, hydrochemistry and isotope results provided in Section 2, groundwater is a contributing source to the K5 pit. The groundwater levels indicate that groundwater flow will be towards the K5 pit. The aquifer and the pit water quality show a similar hydrochemistry, however the isotope results indicate that the pit water has been concentrated because of evaporative processes.

[5] Slight variations in temperature and humidity can affect the slope of the LEL line.

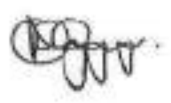
The tritium results indicate that K5 may have a similar source to the aquifer supplying BH8 and BH12 (all recent waters). The aquifer supplying BH10 however was predominantly recharged before the 1950's with less recharge after 1950 when compared to BH8 and BH12 indicating that the aquifer supplying BH10 may be a deeper aquifer of old water, or the fracture system is not recharged as often as BH8 and BH12.

- It is recommended to check the tritium isotopes for all the water supply boreholes to determine if there are any other boreholes which may be drawing water from a deeper or less recharged aquifer; and
- It is also recommended to monitor the tritium isotopes within the water supply boreholes on an annual basis to determine if there are any changes to the aquifer supplying the boreholes (determine if a deeper or less recharged aquifer becomes a more dominant source to the boreholes).

Regards,

Megan Edwards

Hydrogeologist



Levi Ochieng

Principal Geochemist

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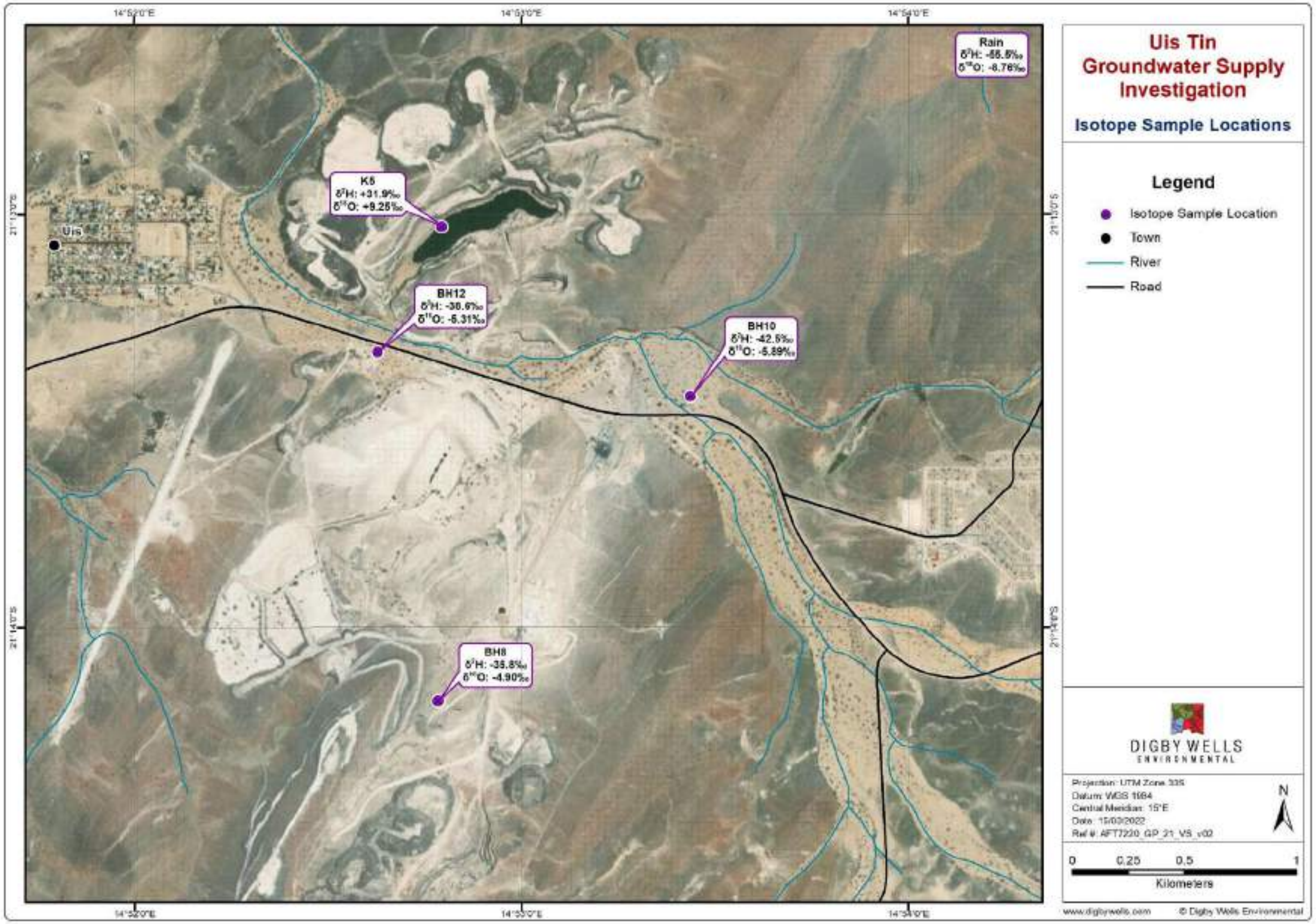

Figure 7: Isotope Sample Locations

To:	Cassidy Kuiper	Date:	July 2022
From:	Digby Wells Environmental	**Proj #:**	AFT7855
RE:	**ESIA Groundwater Responses**		

Dear Cassidy,

AfriTin Mining (Pty) Ltd (hereinafter AfriTin) are planning to construct a bulk sampling processing facility (including a tantalum processing plant and lithium pilot plant) at their Uis Tin Mine, in Namibia. The bulk sampling processing facility is planned to be operational by the end of November 2022 and will require the ESIA (currently being compiled for AfriTin's planned Stage I and II expansion) to be updated to include the additional project infrastructure.

This memorandum provides feedback on groundwater related queries that ECC, the consultants appointed by the client to compile the ESIA for AfriTin.

1. Develop a groundwater management plan, including pumping limitations

A groundwater management plan was developed as part of the hydrogeology assessment (the full details of which are provided in Section 6 of the report). The plan includes the water supply boreholes, their sustainable yield pump rate, operational and maintenance requirements.

The numerical model simulated water supply abstractions for a 24-hour daily rate, which deemed the yields to be sustainable. Site communications confirmed that the water supply abstractions volumes were planned for a 20-hour daily period indicating there would be 4-hours per day to allow the water levels to recover.

Table 1: Water Supply Borehole Management Plan

Water Supply Borehole	Surface Elevation (mamsl)	Operational Times (hours per day)	Currently Used	Sustainable Yield Pump Rate (m^3/hr)	Pump Rate (m^3/d)	Pump Rate (m^3/month)	Current Static / Dynamic GWL (mbgl)[1]	Anticipated Dynamic GWL (mbgl)[2]	Monitoring Requirements	Operational and Maintenance Requirements	
BH1	829	19.7	Yes	0.4	7.9	236	24.2	35.0	Monitor daily abstraction rates and volumes; Monitor rainfall on site; Monitor groundwater levels in active abstraction boreholes on a weekly basis; Monitor groundwater levels in unused boreholes on a quarterly basis; and Monitor water quality on a quarterly basis.	4 hours per day have been allocated to allow water levels to recover in the water supply boreholes. This can be used as a buffer (if needed) to conduct maintenance on boreholes, pumps and/or the reticulation system. Maintenance on the boreholes and/or pumps should be scheduled if there is a drop in the borehole yield or the water levels begin to drop significantly compared with the established trend. Boreholes should be cleaned every 2 years unless the monitoring data indicates a higher frequency is required. The monitoring data collected must be used to recalibrate the numerical model once every two years to confirm the impact to the resource and allow early detection of any water supply issues.	
BH2	827	19.7	Yes	0.2	3.9	118	30.0	42.0			The efficiency of this borehole has declined since 2018. This borehole must be cleaned and retested to verify if the yield can be improved. This borehole may need to be cleaned on an annual basis to maintain yields based on the observed aquifer test response. Monitoring results will confirm this. Consider casing this borehole to reduce the risk of collapse.
BH3	839	19.7	No	0.3	5.9	177	17.1	28.9			Consider casing this borehole to reduce the risk of collapse.
BH4	838	19.7	No	1.0	19.7	590	21.9	35.2			
BH6	845	19.7	No	1.0	19.7	590	17.4	29.3			
BH8	829	19.7	Yes	8.5	167.2	5015	37.0	50.0			
BH9	825	19.7	No	0.9	17.7	531	34.5	49.8			Cleaning out of the roots growing into the borehole and casing. This may lead to blocking flow into the borehole, damage the pump or prevent the pump to be extracted from the hole (e.g. for maintenance). Oxide deposits were observed on the existing pump and the borehole and equipment may need to be cleaned on an annual basis to sustain yields and pump condition. Monitoring results will confirm this.
BH10	824	19.7	Yes	4.0	78.7	2360	33.6	44.9			
BH11	829	19.7	No	1.4	27.5	826	41.3	54.0			Consider casing this borehole to reduce the risk of collapse.
BH12	811	19.7	No	1.0	19.7	590	31.9	45.4			
A	Estimate yield (6.5 m^3/hr)									Locate and aquifer test these boreholes as an alternative water supply borehole to supplement the plant during periods of maintenance on the existing boreholes or should the efficiency of the current boreholes reduce.	
B	Estimate yield (12.2 m^3/hr)										
C	Estimate yield (5.0 m^3/hr)										

[1] Current groundwater level (GWL) is based on the static water level at the time of aquifer testing as a worst-case scenario.
[2] The anticipated dynamic GWL in the boreholes is calculated based on a comparative drawdown with the aquifer testing data with an additional 5 m added to accommodate potential fluctuations in recharge rates and 4.5 m to accommodate regional drawdown impacts.

2. Develop a contaminant plume model for the site. The flow model should show flow rates and contaminants of concern around key mining infrastructure and into the groundwater regime

2.1. Current Use of the V1 and V2 WRD

AfriTin currently operate a tin-tantalum processing plant at their Uis Mine. The tailings from this processing are placed on the V1 and V2 waste rock dumps (WRD) along with waste rock material extracted from the V1V2 open pit.

To establish the quality of in-situ water infiltrated through the current waste material, water samples were collected from the toe of both waste rock dumps after the heavy rainfall events in February 2022. The location of the V1 and V2 WRD and the collected samples are shown in Figure 1. The water quality results were compared against the IFC effluent discharge limits (2007) and are summarized in Table 2. The results indicate that the water samples are compliant with regards to these limits.

2.2. Planned Use of the V1 and V2 WRD

In addition to the tin-tantalum processing, AfriTin are looking to include a bulk sampling and processing for petalite. This processing will involve milling, froth floatation and dewatering to produce petalite concentrate and tailings. The petalite processing will include the use of sulphuric and hydrofluoric acids as well as NaCl and KCl brines in the floatation circuit. To prevent the potential spillages of the acids, the floatation circuit will be within a well ventilated, enclosed room with a concrete floor. The storage tanks will also have concrete bunds built to regulations and best practice guidelines. The acids are only used in the processing of the petalite.

The tailings material generated from processing the petalite has not been geochemically assessed but based on the XRF results of the DMS floats sample, the tailings materials could comprise of quartz, albite, orthoclase, muscovite, cookeite and clay minerals. These are expected to be non-acid forming minerals. However, the use of acids in the processing could potentially mobilise metals and metalloids. The tailings material will be neutralized and dewatered before being deposited on the V1 and V2 WRD facilities. The water will be recycled back to the plant.

The impact assessment for the contamination plume from the V1 and V2 WRDs is provided in Table 4. The impact assessment methodology is provided in Appendix C of the hydrogeology report.

2.3. Recommendations

AfriTin is currently undertaking geochemical assessment of their mining materials to inform the waste management strategy. It is recommended to characterise the petalite tailings when this processing plant becomes operational, to confirm if there are any contaminants of concern that would need to be monitored for and mitigated to be included in their waste management strategy.

The V1 and V2 WRDs are located on the perimeter of the V1V2 open pit (Figure 1). Should a significant rainfall event occur which would potentially generate seepage, the seepage will be drawn towards the V1V2 open pit which would act as a groundwater sink, given the high evaporation rates of the area. This will assist in managing any potential contamination plumes from the V1 and V2 WRD facilities. Water supply boreholes BH8 and BH11 are located downgradient of the V1 and V2 WRD and the abstraction from these boreholes will draw groundwater to these locations, where not captured by the V1V2 open pit. These two boreholes must also be included into the monitoring network for the V1 and V2 WRD (Table 3). The WRD1 and WRD2 collected points are included in the monitoring plan for the V1 and V2 WRDs, however should any additional runoff / seepage points be identified during storm events, these must be sampled as well.

Table 2: V1 and V2 WRD Water Quality Compared to the IFC Effluent Guidelines

Constituent	Guideline Value	Unit	WRD1 (V1 WRD)	WRD2 (V1 WRD)
Total suspended Solids	50	mg/l	34	5
pH	6 – 9	S.U.	8.04	7.71
COD	150	mg/l	-	-
BOD_5	50	mg/l	-	-
Oil and Grease	10	mg/l	-	-
Arsenic	0.1	mg/l	<0.001	<0.001
Cadmium	0.05	mg/l	<0.001	<0.001
Chromium (VI)	0.1	mg/l	-	-
Copper	0.3	mg/l	0.004	0.007
Cyanide	1	mg/l	-	-
Cyanide Free	0.1	mg/l	-	-
Cyanide WAD	0.5	mg/l	-	-
Iron (total)	2	mg/l	0.394	0.023
Lead	0.2	mg/l	<0.012	<0.012
Mercury	0.002	mg/l	-	-
Nickel	0.5	mg/l	<0.007	<0.007
Phenols	0.5	mg/l	-	-
Zinc	0.5	mg/l	<0.006	<0.006

Table 3: V1 and V2 WRD Monitoring Network

Location	Frequency	Parameters
Pit	When present	pH, electrical conductivity, TDS, TSS, Ca, Mg, Na, K, Alk, Cl, SO_4, Al, As, Cd, Cu, Fe, Pb, Ni, Zn as a minimum
WRD1	After storm events	
WRD2	After storm events	
BH1 (background)	Quarterly	
BH8	Quarterly	
BH11	Quarterly	

Table 4: Contamination Impacts from the V1 and V2 WRD

<table>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td colspan="4">Activity and Interaction: Disposing of waste rock and tailings on waste rock dumps</td></tr>
<tr><td colspan="4">Impact Description:
Exposing minerals to oxidising conditions and residual acids from the petalite processing potentially resulting in contamination.</td></tr>
<tr><td colspan="4">Prior to Mitigation/Management</td></tr>
<tr><td>Duration</td><td>5</td><td>The impact can occur during the project life</td><td rowspan="5">Negligible (negative) -10</td></tr>
<tr><td>Extent</td><td>1</td><td>Limited to isolated parts of the site</td></tr>
<tr><td>Intensity</td><td>1</td><td>Minimal to no loss and/or effect to the biological and physical resources</td></tr>
<tr><td>Probability</td><td>4</td><td>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">• Undertake a geochemical assessment of the tailings material when sample material becomes available to determine any contaminants of concern and recommendations to manage these;
• Continue sampling the seepage water from the V1 and V2 WRD after rainfall events to assess for any water quality changes;
• Include sampling of the pit water, if and when this is present;
• Include sampling of BH8 and BH11 water quality on a quarterly basis to establish current quality from which future impacts can be assessed; and
• The V1V2 open pit will act as a groundwater sink drawing seepage (when generated during significant rainfall events) towards the pit, limiting the potential for contamination from these facilities to migrate from the site.</td></tr>
<tr><td colspan="4">Post-Mitigation</td></tr>
<tr><td>Duration</td><td>5</td><td>The impact can occur during the project life</td><td rowspan="5">Negligible (negative) -9</td></tr>
<tr><td>Extent</td><td>1</td><td>Limited to isolated parts of the site</td></tr>
<tr><td>Intensity</td><td>1</td><td>Minimal to no loss and/or effect to the biological and physical resources</td></tr>
<tr><td>Probability</td><td>3</td><td>Unlikely</td></tr>
<tr><td>Nature</td><td>Negative</td><td></td></tr>
</table>

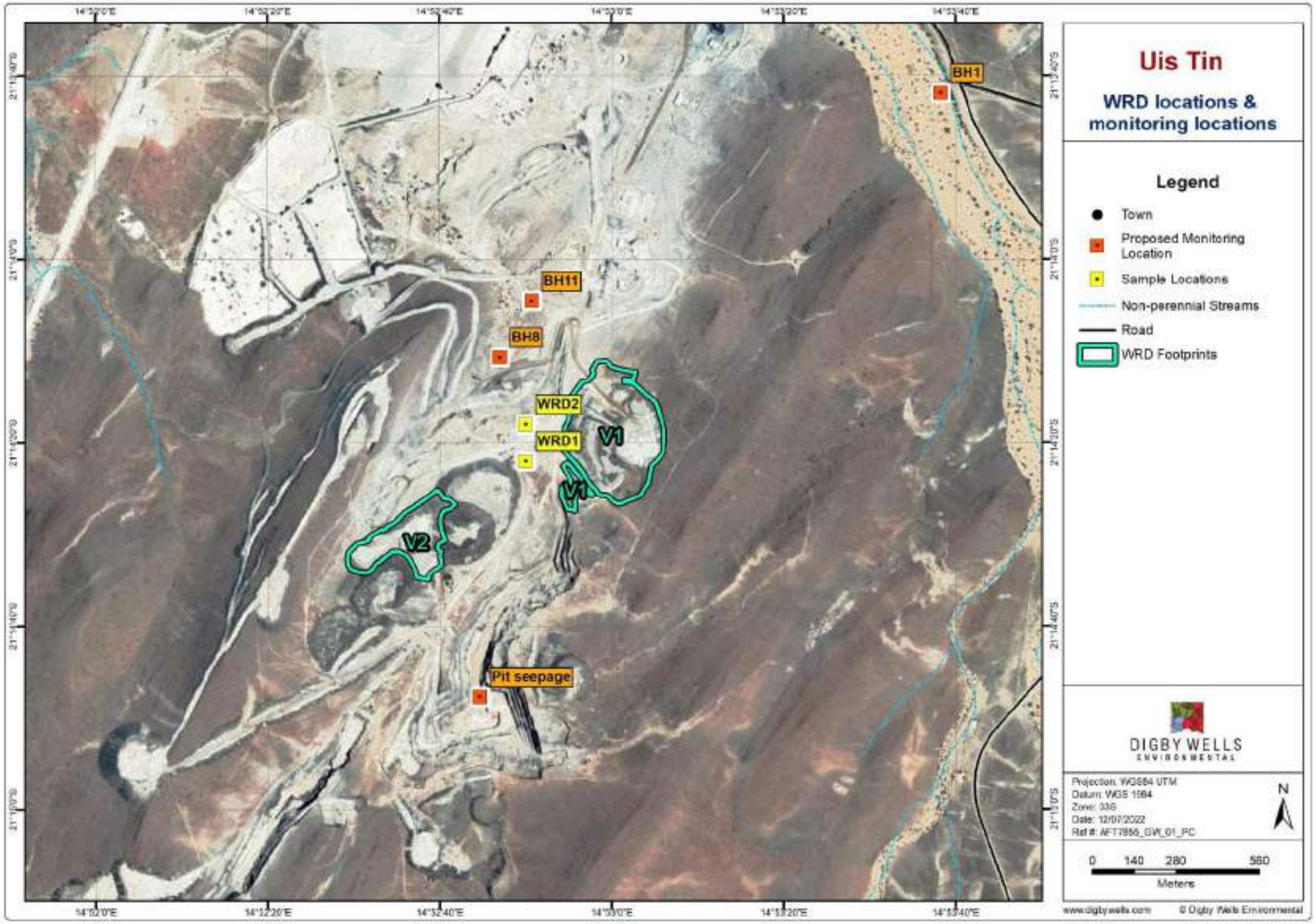

Figure 1: Waste Rock Dump Locations and Sample Locations

3. Sustainable yield per borehole and the area. This should include sustainable use of the aquifer

The sustainable yield for the available water supply boreholes were assessed as part of the recent hydrogeological assessment, the aquifer testing methodology of which can be found in Appendix A.

The sustainable yield per borehole is provided in Table 5 below. These values were simulated as abstraction values for the water supply boreholes for an 18-year Life of Mine period. The resulting drawdown cone will extend ~6.5 km from the mine and will have a drawdown of ~4.5 m in the area of the wellfield. The numerical model results indicate the abstractions will be sustainable, however they will stress the aquifer due to the low recharge potential of the area.

Based on the rainfall data available for the area (from 1979 to present), there are regular peak rainfall events that assist with recharging the aquifer, as was observed in during the first few months of 2022 after a major rainfall event. Groundwater level observations on site showed an increase in groundwater levels in the water supply boreholes of between 0.8 – 8.3 m, in response to the site receiving ~90 mm of rainfall.

Table 5: Sustainable Yield per Borehole

Borehole	Average Sustainable Yield	Borehole	Average Sustainable Yield
BH1	0.4	BH8	8.5
BH2	0.2	BH9	0.9
BH3	0.3	BH10	4.0
BH4	1.0	BH11	1.4
BH6	1.0	BH12	1.0
Total Yield		**18.7**	

4. Alternative water supply options, consideration and assessment

All the available water supply boreholes for the Uis Tin Mine were assessed and will be required to meet the water demand for the Phase 1, Stage II requirements, the following alternative options can be considered:

- AfriTin plan to dewater the K5 pit which contains an estimate volume of 190 634 m^3. The timeframe for this has not been confirmed but it is recommended to plan this as far in advance as possible to reduce discharging the stored water to the environment and accommodate any dilution of the pit water may be required. The pit water has higher concentrations compared to the groundwater aquifer as a result of evaporation, which may limit its use in the plant unless this can be diluted;

- AfriTin could consider establishing a covered water storage area nearby to the plant, with a minimum capacity of 1 week (~2 700 m^3) supply for emergency water supply;
- There are potentially three boreholes located within ~13 m of the mine, which could be located and tested for an additional water supply to the mine and to assist with down time associated with maintenance on the water supply boreholes. The estimate yield from these borehole could provide an additional 23.7 m^3/hr for the project but this would need to be confirmed;
- Should the above borehole not be located, it is recommended that AfriTin establish additional water supply boreholes for emergencies or to allow flexibility on the current water supply network. These should preferably be outside the Uis River Catchment to reduce cumulative drawdown impacts within this catchment;
- Where processes allow for it, water used in the plant should be recovered and reused as much as possible. The reticulation system must be maintained to reduce losses from the system;
- If possible water from the Uis wastewater treatment works could be recovered and used to supplement the water supply for the plant; and
- When possible AfriTin could consider collecting and storing rainwater in non-operational pit areas which could provide a temporary supplement to the plant.

5. Review and update the groundwater status report prepared for Uis Tin Mine in 2019 based on the results from monthly monitoring results between 2019 and 2021 (if required)

The groundwater status report was not available for review.

During the hydrogeological assessment water quality samples were taken from the water supply boreholes between December 2021 and January 2022. These are compared with 2018 water quality data collected during van Wyk's drilling and aquifer testing project.

pH, electrical conductivity and total dissolved solids were used to describe the general condition of the groundwater. The trends for pH (Figure 2) and electrical conductivity and total dissolved solids (Figure 3) indicate that the results for the water supply boreholes are of a similar range to the boreholes tested in 2018.

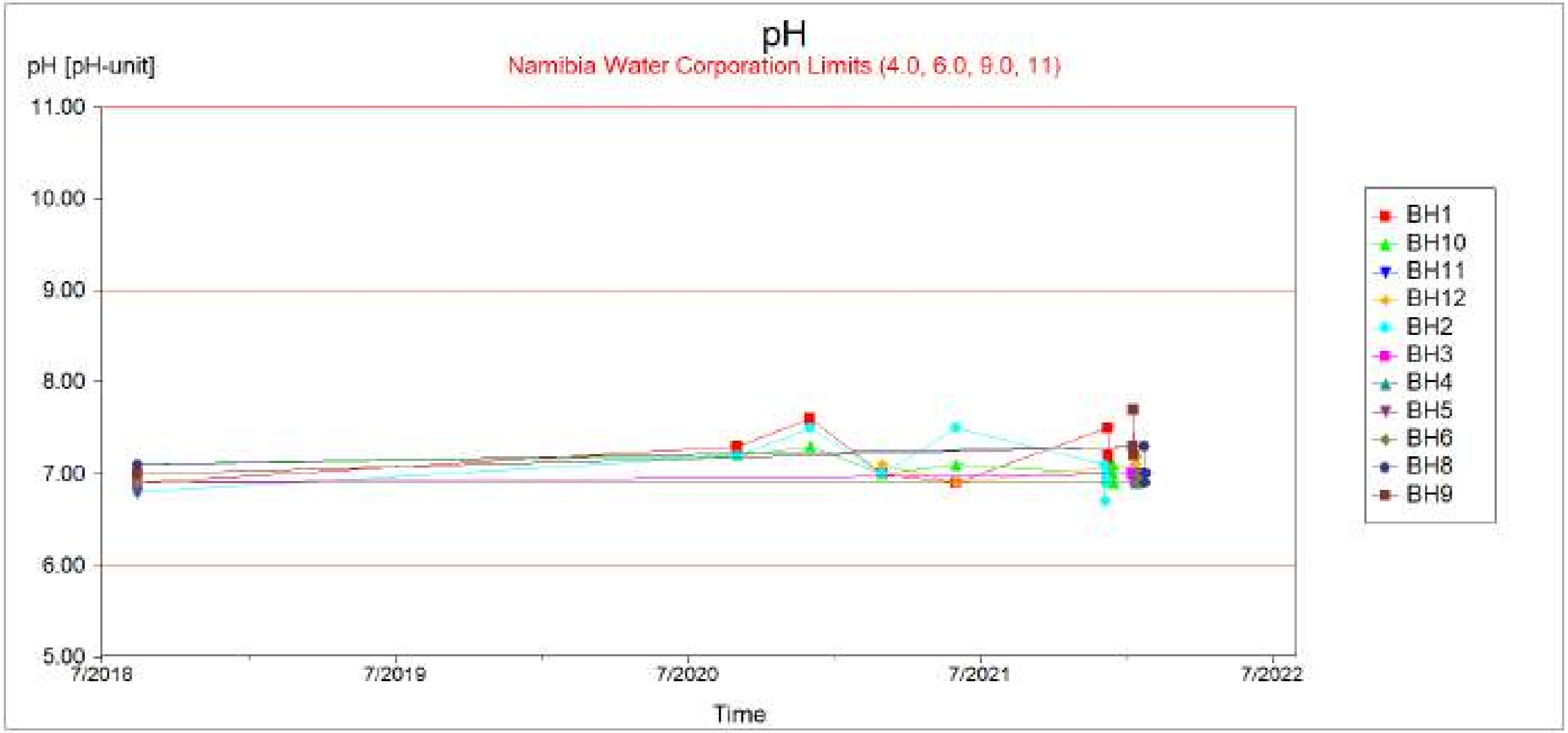

Figure 2: pH Trend

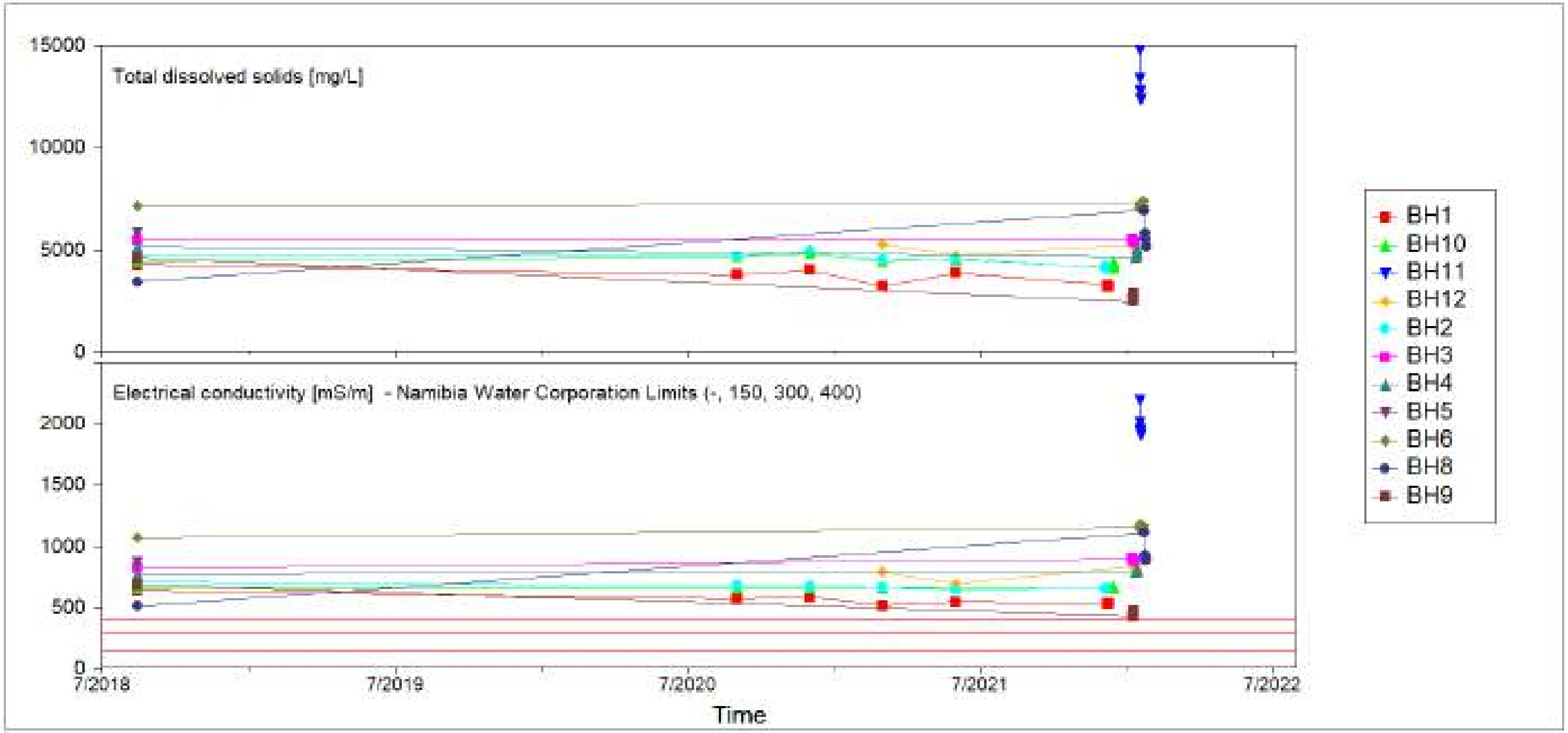

Figure 3: Electrical Conductivity and Total Dissolved Solids Trends

6. Review the feasibility of alternative water supply options as presented in a 2018 report titled: An appraisal of water supply alternatives for the pilot plant by van Wyk)

Eight alternative water supply options were presented in the van Wyk report, which are summarised here in order of feasibility:

- Former IMKOR water supply scheme:
  - IMKOR boreholes located in the southern wellfield area were investigated for water supply as part of the hydrogeological assessment. These boreholes were drilled outside of the alluvial river systems and were not deemed feasible for a sustainable water supply as they were potentially over pumped. Additional boreholes were drilled in the alluvial channels nearby, by van Wyk. These new boreholes can provide a low yield, with a combined of 2.3 m^3/hr according to the current testing and modelling results. The lower yield would make the water supply from these boreholes more sustainable, and these have been included in the current water supply network;
  - The Uis River alluvial aquifer currently supplies the mine, other businesses and the local community. The mine currently has four (4) boreholes in the alluvial aquifer of the Uis River channel which can provide a combined yield of 5.6 m^3/hr. The demand from this catchment is quite high and establishing any additional (new) water supply boreholes in this catchment would have cumulative drawdown impacts on this aquifer which would further stress this aquifer. Developing new boreholes in this wellfield is not recommended, unless replacing non-functioning existing boreholes. Additional boreholes could be placed in adjacent river channels;
- Karibib marbles at Nei-Neis WSS was identified as a feasible option. The marbles are located downstream of the wellfield and the potentially moderate to high yielding marbles could be recharged by the Omaruru River. This target area was assessed during the desktop review phase of the geophysical assessment. One target was identified in this location to intersect the marble schist contact below the alluvial channel, downstream of the NamWater wellfield. Higher priority targets were chosen for the field investigation as the geological map and provided cross-sections indicated that the marble in this area is significantly folded potentially isolating it from the marbles to the east, limiting the recharge to the potential fractures that intersect the Omaruru River. Additional work would be required to determine if this is a feasible option;
- Karibib marbles (near Peak Reservoir) was identified as a feasible option as marbles have the potential to be moderate to high yielding aquifers, if karstic features have developed within the unit. However, the marbles near the peak reservoir are located on a water divide between two (2) catchments which would receive limited recharge

potentially reducing the sustainability of this source for the long term. This could still be considered a feasible option, however, additional work would be required;

- Khai Nuses was identified as a feasible option, located ±4 km north of the mine. The report indicates there is a strong yielding borehole used by the community in the area. This option could have a similar aquifer potential to Uis River but would need to be investigated further. As this wellfield would be in a neighboring river catchment, developing a wellfield here would ease the dewatering effects of the Uis river catchment. This could still be considered a feasible option however additional work would be required;
- Uis water was not deemed a feasible option on the basis of the aquifer being low yielding and not able to meet the demand from the mine. The use of this wellfield was discontinued once Nei-Neis was commissioned. According to the report there is one functioning borehole and reservoir which is used by the community. Additional work would be required to consider this option as feasible for low yielding backup supply;
- Mine Quaries were noted as a feasible standby option, with consultation from the owner of the fishery. As this source is used to provide a livelihood, the volume and duration of use would be limited. The feasibility of using the quarries to recharge the aquifer will be low, given the low rainfall and high evaporation of the project area. As an emergency standby option this would be feasible, however the supply would be temporary and limited and agreements with the fishery owner would need to be in place;
- Compartment C&D in the Omaruru River was not deemed a feasible option for water supply. The motivation for this would be the potential damage to infrastructure during flood periods and the use of this aquifer by NamWater. Development of water supply boreholes within this area would need to consider the requirements of NamWater and drawdown impacts to the wellfield located downstream. This option is not recommended; and
- Surplus capacity from Nei-Neis Scheme of NamWater was not considered a feasible option as the groundwater levels may reach critical levels in future, as the system has previously been severely strained in 1983, 2006 and 2016. This option is not recommended.

As part of the water supply assessment a geophysical survey was undertaken for AfriTin, identifying eight (8) borehole locations that are proposed for further investigation.

It was also recommended to try and locate existing boreholes within the identified regional target areas and determine if these could be used and if so, what their sustainable yields would be. If yields would be sufficient, these could provide an alternative groundwater supply source to the mine.

Drawing large yields of groundwater for prolonged periods may have significant drawdown impacts for the regional aquifers. Alternative water supply options such as piping water from the Orano Desalination plant or directly from the sea should also be considered for the project (as mentioned alternatives in the AfriTin's Phase 1 Potential Regional Groundwater Resources report).

7. Determine the interconnectedness between groundwater and surface water resources

Stable isotopes can be used to determine the origin of groundwater based on their abundance and variations. An isotope assessment was undertaken for samples collected from multiple water supply boreholes, K5 pit water and rainfall sources.

The results indicate that the groundwater samples are meteoric (derived from precipitation or fresh surface water) which have been enriched with heavier isotopes because of evaporation processes. Although all samples indicate the groundwater samples have a meteoric origin, the tritium isotope results indicates that the age of one of the three groundwater samples (BH10) comprises of water with an age closer to 1953, indicating this borehole is not recharged as often or accesses a deeper aquifer of older water and therefore may be less connected to the surface water river channels.

In addition to the isotope assessment, observations made during the 2022 field investigations showed a rise in groundwater levels by between 0.8 – 8.3 m in response to the rainfall events which occurred in January and February.

Although the surface water resource (when available) contributes to the recharge of the groundwater aquifer, the groundwater levels currently occur below the alluvial aquifer of the river channels (or within the fractured aquifer) at the project area, and therefore it is unlikely that the groundwater aquifers will contribute to the baseflow within the river channel. The groundwater resource however does provide a source of water to the K5 pit void.

8. Determine the appropriate recovery period for boreholes after drawdown limits are reached till water levels are recovered

The borehole recover period was not simulated as part of the numerical model simulations. This was completed using an analytical approach. Recovery simulations can be included in future model updates. However, an indication was derived based on the area of influence, aquifer storage and recharge.

The numerical model simulations indicate that when the end of mine is reached and the abstraction requirements cease the drawdown cone will extend ~6.5 km from the mine with a drawdown of ~4.5 m in the wellfield area. The drawdown contours were used to calculate the area for the dewatered extent and the dewatered volume using ArcGIS version 10.8.1. This was used in conjunction with the porosity factor (numerical model) and recharge to calculate that the estimated water level recovery period would be 58 years post closure (Table 6).

Table 6: Analytical Calculation Inputs

Input	Value	Unit
Area of influence	65 075 284	m^2
Dewatered volume	228 472 561	m^3
Porosity[3]	0.01	%
Volume of pore space to be filled	2 284 726	m^3
Recharge	0.61	mm/a
Recharge over area of influence	39 696	m^3/a
Time to Fill area of influence	58	years

9. Recommend strategic measures to be included in an abstraction and groundwater and surface water management plan for Uis Tin Mine

The groundwater management plan for the abstraction boreholes is provided in the hydrogeological report (Section 6 of the Hydrogeology report) and summarised in Section 1 of this memorandum.

It is recommended to include the proposed monitoring locations for the V1 and V2 WRD locations as proposed in Section 2 of this memorandum to monitor the groundwater quality with regards to the disposal of waste and tailings on the V1 and V2 waste rock dumps.

10. Mitigation measures and thresholds of water quality parameters and water levels should be incorporated into the groundwater management plan

The following mitigation measures can be included based on the impact assessments done:

- Water quality thresholds and mitigation measures:
  - The IFC effluent limits are suitable to assess the contamination of the site. The samples collected from the V1 and V2 WRD rainfall runoff are currently compliant with these limits. The pit and proposed groundwater monitoring locations (Section 2) will need to be sampled for assessment against these limits still;
    - Although the major ion chemistry is not included in the IFC effluent limits, the concentrations of the major ions in the groundwater samples are more elevated (in the order of $3x10^2$ to $1.5x10^3$) compared with the major ions in the WRD1 and WRD2 samples (which are in the order of

[3] The analytical calculation assumes the porosity factor for the weathered aquifer is applicable for the dewatered area.

$1x10^1$ to $3x10^2$). These results are considered natural values due to the long residence time of the water within the aquifer. Should any of the IFC effluent limits be exceeded in the V1 and V2 downgradient monitoring boreholes, it is recommended to compare the results to the proposed background monitoring borehole (BH1) for comparison, to verify if the results could be related to naturally occurring conditions;

  - Undertake a geochemical assessment and waste classification of the tailings material when sample material becomes available to determine any contaminants of concern and recommendations to manage these;
  - Continue sampling the seepage water from the V1 and V2 WRD after rainfall events to assess for any water quality changes;
  - Include sampling of the pit water, if and when this is present;
  - Include sampling of BH8 and BH11 water quality on a quarterly basis to establish current quality from which future impacts can be assessed; and
  - The V1V2 open pit will act as a groundwater sink drawing seepage (when generated during significant rainfall events) towards the pit, limiting the potential for contamination from these facilities to migrate from the site.
- Water level threshold and mitigation measures:
  - The anticipated dynamic groundwater level provided in the water supply management plan (Table 1) for each borehole can be used as the threshold limit for the water supply boreholes;
  - Implement best practice and investigate new technologies to use water as efficiently as possible during the LoM;
  - Collect stormwater runoff (when available and where possible);
  - Manage abstraction from the borehole wellfield aligned with a water management plan;
  - Implement regular borehole maintenance to maintain and/or improve individual borehole yields (reduce scaling, fouling, precipitation of oxides and root growth into the boreholes);
  - Drill additional water supply boreholes, or locate existing ones, near the mine, and use these as backup water supply, for instance during borehole maintenance;
  - Continue monitoring the groundwater levels on a weekly basis to monitor any fluctuations, and comparisons of groundwater levels against predicted drawdowns;

- Monitor abstraction rates and volumes from the water supply boreholes on a weekly basis;
- Monitor daily rainfall on-site; and
- Monitor the quality of water abstracted from the water supply boreholes on a quarterly basis to be able to discern changes or fluctuations in quality which may indicate hydrochemical changes of groundwater in the aquifers and/or boreholes.

11. Assumptions for Determining the Impact of the Uis Mine Abstractions

An assumption (below) was included in the hydrogeological report, on which it was requested to expand upon:

- The daily abstractions for third-party groundwater users are unknown and were assumed to be 200 m^3/d for the borehole at the Brandberg Rest Camp (which currently being used to supply large volumes for road construction) and 100 m^3/d for the NamClay borehole. It is understood that the abstraction from the Brandberg Rest Camp is only expected to continue for the next 18 months, however the assumed abstraction values for both third-party boreholes were modelled for the duration of the Life of Mine as a worst-case scenario.

The abstractions for the Brandberg Rest Camp and NamClay were included in the forward, transient numerical model to account for the existing stresses on the aquifer and achieve a representative simulation taking into account groundwater level trends prior to the Phase 1 Stage II water supply abstractions. It must be noted that the predicted impacts were compared to the groundwater levels as they were at the start of 2022, which already account for historical abstraction impacts by third-party users and historical abstraction by the Uis mine.

Including the third-party water supply for the duration of the Phase 1 Stage II life of mine provides a cumulative impact for the area as a worst-case scenario for AfriTin. As the third-party abstractions are not anticipated to take place for the full duration of the Phase 1 Stage II life of mine, the extent of the drawdown cone and drawdown in the aquifer may be less than the predicted outcome in the hydrogeological report.

However, by including the third-party abstractions for the full duration even though the third-party users are not expected to abstract for the full duration, allows some flexibility for changes to occur from these users, should larger abstraction volumes be abstracted again from the third-party users later in the Phase 1 Stage II life of mine. Should these abstractions occur, provided they are not more than the assumed requirements, it would not be expected to impact the water demand for AfriTin as the cumulative abstraction requirements would already accounted for.

Regards,

Megan Edwards

Hydrogeologist

Arjan van 't Zelfde

Divisional Manager: Water Geosciences

DIGBY WELLS
ENVIRONMENTAL

To:	Cassidy Kuiper	**Date:**	July 2022
From:	Ofentse Mokonoto	**Proj #:**	AFT7855
RE:	**Surface Water Inputs for Uis Tin Mine ESIA Update**		

Dear Cassidy,

It is Digby Wells Environmental (hereinafter DWE) understanding that AfriTin Mining (Pty) Ltd (hereinafter AfriTin) are planning to construct a bulk sampling processing facility (including a tantalum processing plant and lithium pilot plant) at their Uis Tin Mine, in Namibia. The proposed construction will require an Environmental Social Impact Assessment (ESIA) which is currently being undertaken by AfriTin.

This memorandum provides feedback on surface water-related queries that the ESIA consultants have.

1. Hydrology and Topography

DWE is of the view that floodline modelling will not be required for the proposed activities. The nearest watercourse with substantial streamflow during a heavy rainfall event is on the eastern side of the mountain ridge. The 1:50 and 1:100 year floodlines were delineated by DWE (Digby Wells Environmental, 2022) floodline report which was provided to AfriTin.

There is a non-perennial drainage line flowing in a south-westerly direction from the hills and along the plant area (see Figure 1-1). However, the drainage line is deemed too small to collect any significant amount of runoff that can potentially cause flooding to the planned mining infrastructure site. A berm extending across the foot of the mountain will therefore be required to prevent clean water from entering the plant area. See Section 1.1 for the recommended height.

Based on the plant layout provided by AfriTin (see Figure 1-1), there is a proposed clean water channel which will collect all the runoff from upstream of the plant area and divert it along the southern boundary towards the old pit area. Alongside the clean water channel, there is a berm that will prevent the clean water from entering the plant area. DWE proposes the berm is extended north around the plant area to prevent runoff from the hills from entering the plant area.

Based on the topography of the catchment, during a significant rainfall event, runoff from the hills will be captured by the proposed clean water channel and will divert water past the plant area and towards the pit area (west of the proposed process facility). As indicated in Figure 1-1, some of the runoff from the hill will follow the gradient of the topography towards the road and will flow along the road in a north-easterly direction towards Namclay Bricks and Pavers.

Digby Wells and Associates (South Africa) (Pty) Ltd
Company Registration: 2010/008577/07

Turnberry Office Park, Digby Wells House. 48 Grosvenor Road, Bryanston,2191

Phone: +27 (0) 11 789 9495
Fax: +27 (0) 11 789 9495
E-mail: info@digbywells.com
Website: www.digbywells.com

As indicated above, the proposed berm will allow the runoff to be diverted away from the plant area. With these berms in place, clean water runoff from the hills will not enter the plant area.

1.1. Conceptual Sizing of the Clean Water Channel

It is important to ensure that all stormwater structures (see Figure 1-1) that will be designed to keep dirty and clean water separate should accommodate the magnitude of the precipitation event for a 1:50 year, 24-hour event. This is in line with the Best Practice Guidelines and in line with the South African National Water Act (Act 36 of 1998) as well as the Government Notice 704 (Government Gazette 20119 of June 1999). As per the scope of work, this memo only provides the conceptual sizing of the stormwater infrastructure outside the plant area to avoid clean water runoff entering the plant area.

The Manning Equation was used to provide a conceptual size of the clean water channel. The Manning Equation is described by the following equation *V = (1 / n) x R2/3 x s1/2*.

Where:

- V- Velocity or water mass flow rate;
- n - Manning's roughness coefficient;
- R - The channel's hydraulic radius, calculated by dividing the water flow's cross-sectional area “A” by its wetted perimeter P (i.e., R = A / P); and
- s - Slope of the channel's bottom surface.

The dimensions and characteristics of the proposed clean water channel are presented in Table 1-1. The stormwater channels should be sized to convey the 1:50-year return period flood peak in accordance with the best practice guidelines. It is assumed that the channels will have a slope of at least 2%. The Manning’s roughness coefficient assumed for the proposed clean water (concrete) channel was 0.013 (see Table 1-1). The 1:50 and 1:100 year Floodlines Report (Digby Wells Environmental, 2022) indicated that the 24-hour design rainfall depths for a 1:50-year is 56 mm. The proposed berms should have a minimum height of at least 0.6 m.

Table 1-1: Proposed Storm Water Channel Characteristics

Name	Shape	Depth (m)	Top Width (m)	Bottom Width (m)	Max Velocity (m/s)	Max Velocity (m^3/s)	1:50 Year Peak Flow (m^3/s)
Catchment A	Trapezoidal	0.40	0.92	0.46	3.7	1.03	1.0

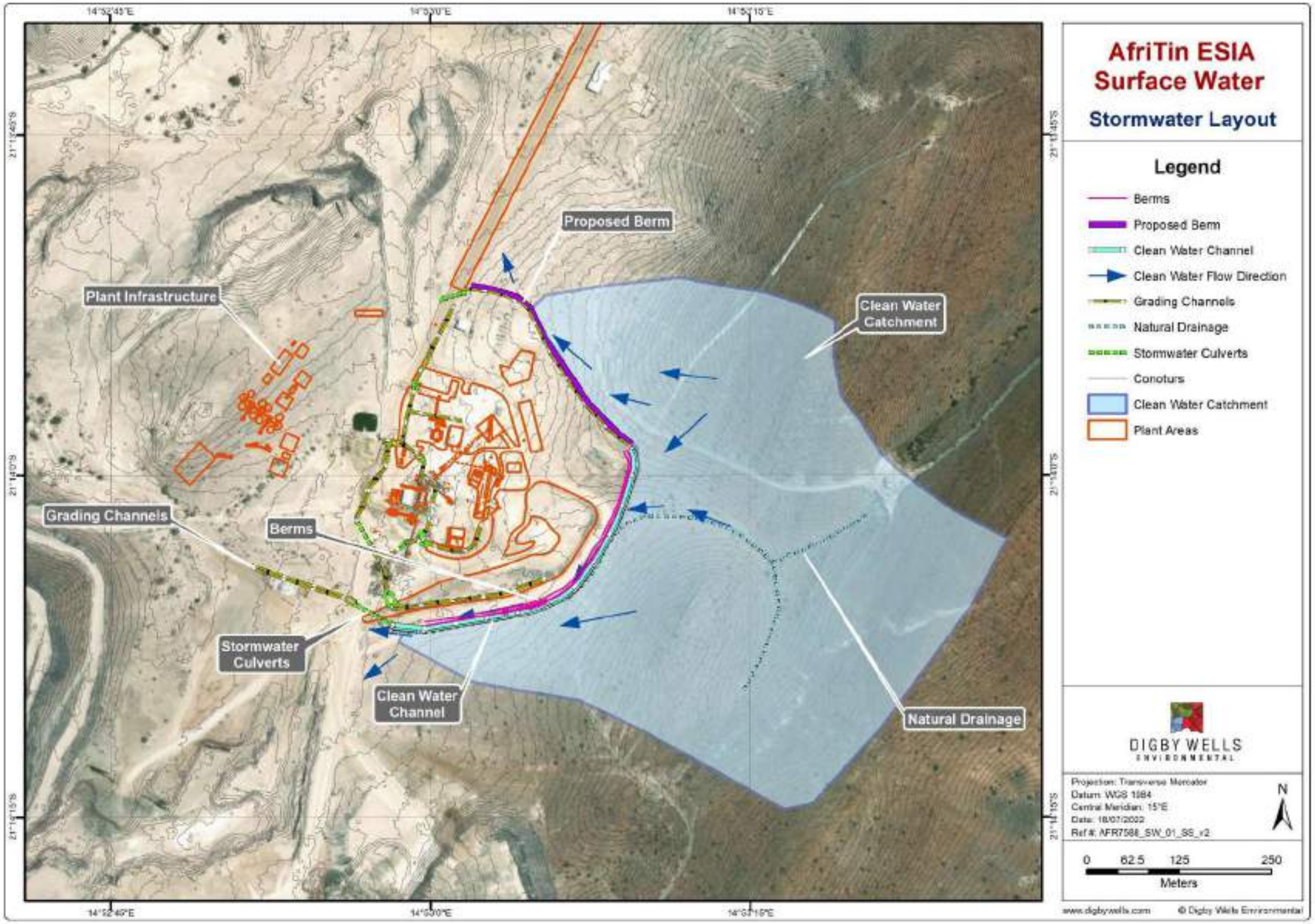

Figure 1-1: The Proposed Plant Upgrade Layout

2. Surface Water Impact Assessment

The Surface Water Impact Assessment (SWIA) includes the description of the potential and existing surface water impacts of the project activities on water resources (i.e., runoff from the hills) and the mitigation/management recommendations. The impacts were rated as the indicated methodology in **Appendix A**.

Since AfriTin is an existing mine, and as such this study will only consider potential impacts for the operational phase and decommissioning phase. This impact assessment does not consider the impacts of the proposed bulk sampling and processing plant, because this is addressed in the **ESIA Groundwater Responses memo**.

Similar projects were researched to identify additional impacts and risks and were compared to the context of the proposed development.

2.1. Operational Phase

The project site (i.e., plant area) is situated adjacent to an unnamed drainage line and any runoff from the site (without any mitigations) would end up in the natural environment. Activities during the operational phase that may have potential impacts on the surface water resources are presented in Table 2-1 and the appropriate management/mitigation measures are provided below.

Table 2-1: Interactions and Impacts of Activity

Interactions	**Impacts**
Runoff from the Waste Rock Dumps (WRD) footprint	1. Siltation and sedimentation as runoff from the WRD can report the nearby drainage line
Loading, hauling and stockpiling of overburden material and waste rock.	
Runoff from the contaminated surface due to moving trucks during transportation of materials	2. Surface water contamination due to runoff from contaminated areas leading to deteriorated water quality
General operation of operation of plant, ancillary infrastructure and services (including use of vehicles and machinery as well as storage and handling of waste and hazardous material).	
Capturing runoff water and precipitation	3 Reduction in catchment size and less runoff to the environment

2.1.1. Impact Description: Sedimentation and siltation of nearby watercourses from the plant area (Interactions 1&2)

Under a significant rainfall event and without any mitigations in place, runoff from the WRD and surrounding contaminated areas could potentially mix with the surface runoff from the adjacent hills. This would potentially lead to siltation and sedimentation of the non-perennial drainage line. Under the Best Practice Guidelines, the mixing of clean and dirty water is prohibited.

2.1.2. Impact Description: Contamination of water resources and deterioration of water quality (Interactions 1&2)

Hydrocarbon spillages and leakages from services workshops, maintenance of haul roads, and machinery as well as general waste could potentially end up in the adjacent drainage line under a heavy rainfall event. This could lead to surface water contamination. It is understood that the tailings material will be neutralized and dewatered before being deposited on the WRD facilities. However, during a rainfall event, these tailings materials could end up in the adjacent drainage line if there are no measures to prevent the mixing of clean and dirty water.

2.1.3. Impact Description: Reduced runoff reporting to the environment

The reduction in catchment size will subsequently reduce the amount of runoff entering the natural environment. This could result in the modification of the localised water balance/hydrology. However, the impact is likely to be negligible because the catchment of the mining activity is small in comparison to the catchment of the affected watercourse. In addition, the catchment is already disturbed and therefore the impact will be minimal.

2.1.4. Impact Rating

The following tables (Table 2-2 to Table 2-4) rate the impacts of the operational phase:

Table 2-2: Impact Significance Rating for Sedimentation and Siltation

Dimension	Rating	Motivation	Significance
Activity and Interaction: Runoff from WRDs and loading, hauling and stockpiling of waste materials			
Impact Description: Sedimentation and siltation of the adjacent non-perennial drainage line from the WRD and surrounding contaminated areas.			
Prior to Mitigation/Management			
Duration	5	The impact will likely occur during the operational phase. Impact will cease after operation	-24 Negligible (Negative)
Extent	1	Very limited. Limited to isolated parts of the project site.	

Dimension	Rating	Motivation	Significance
Intensity	2	Minor natural impacts which are mostly replaceable. Very little change to the baseline. Damages can be rehabilitated. The drainage line hardly has flowing water.	
Probability	3	There is a possibility that the impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
• Erect vegetated berms along the eastern portion of the plant area to divert surface water runoff from the hills away from the plant; • Implement vegetated berms around stockpiles to limit soil erosion; • Construct a clean water channel to divert the surface water runoff from the hills; • Ensure a storm water management plan is in place and implemented so that contaminated runoff from dirty catchment areas is contained; • All stormwater drainage infrastructure should be designed to contain the 1:50-year rainfall events to reduce the potential of contaminating water courses; • Install silt fences, and erosion blankets prior to soil stabilisation on steep surfaces to reduce chances of erosion; and • Water quality monitoring should continue to detect any potential sources of pollution.			
Post-Mitigation			
Duration	5	The impact will likely occur during the operational phase. Impact will cease after operation	-14 Negligible (Negative)
Extent	1	Very limited. Limited to isolated parts of the project site.	
Intensity	1	With mitigations in place, it is envisaged that there will be minor to no impact on the environment.	
Probability	2	With mitigations in place the possibility of the impact happening is very low.	
Nature	Negative		

Table 2-3: Impact Significance Rating for Contamination of Water Resources

Dimension	Rating	Motivation	Significance
Activity and Interaction: Contamination of water resources due to runoff from contaminated surface and general mining operations			

Dimension	Rating	Motivation	Significance
Impact Description: Contamination of water resources			
Prior to Mitigation/Management			
Duration	5	The impact will likely occur during the operational phase. Impact will cease after operation	-24 Negligible (Negative)
Extent	1	Very limited. Limited to isolated parts of the project site.	
Intensity	2	Minor natural impacts which are mostly replaceable. Damages (if any) can be rehabilitated.	
Probability	3	There is a possibility that the impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
• Erect vegetated berms along the eastern portion of the plant area to divert surface water runoff from the hills away from the plant; • Implement vegetated berms around stockpiles to limit soil erosion; • Construct a clean water channel to divert the surface water runoff from the hills; • Ensure a storm water management plan is in place and implemented so that contaminated runoff from dirty catchment areas is contained; • All stormwater drainage infrastructure should be designed to contain the 1:50-year rainfall events to reduce the potential of contaminating water courses; • All storage areas for fuels, paints and oils should be appropriately bunded and spill kits should be in place; and • Water quality monitoring should continue to detect any potential sources of pollution.			
Post-Mitigation			
Duration	5	The impact will likely occur during the operational phase. Impact will cease after operation	-14 Negligible (Negative)
Extent	1	Very limited. Limited to isolated parts of the project site.	
Intensity	1	With mitigations in place, it is envisaged that there will be minor to no impact on the environment.	
Probability	2	With mitigations in place the possibility of the impact happening is very low.	
Nature	Negative		

Table 2-4: Impact Significance Rating for Reduction in Runoff

Dimension	Rating	Motivation	Significance
Activity and Interaction: Capturing runoff water and precipitation			
Impact Description: Reduced runoff entering the natural environment.			
Prior to Mitigation/Management			
Duration	5	The impact will likely occur during the operational phase. Impact will cease after operation	-21 Negligible (Negative)
Extent	1	Very limited. Limited to isolated parts of the project site.	
Intensity	1	Limited damage to minimal area. The catchment area is already disturbed.	
Probability	3	There is a possibility that the impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
• Allow some of the rainfall/runoff water to flow freely into the environment, • Constructing a clean water open drain that will collect some of the water currently flowing towards the plant site and allow it to flow to the environment; and • Construct berms to divert water away from the plant area and allow this to seep away into the environment.			
Post-Mitigation			
Duration	5	The impact will likely occur during the operational phase. Impact will cease after operation	-14 Negligible (Negative)
Extent	1	Very limited. Limited to isolated parts of the project site.	
Intensity	1	With mitigations in place, it is envisaged that there will be minor to no impact on the environment.	
Probability	2	With mitigations in place the possibility of the impact happening is very low.	
Nature	Negative		

2.2. Decommissioning, Rehabilitation and Post Closure Phases

Table 2-5 outlines the potential impacts to surface water which could arise during the Decommissioning and Rehabilitation Phase.

Table 2-5: Interactions and Impacts of Activity

Interaction	Impact
Demolition and removal of infrastructure	1. Sedimentation and siltation of the nearby drainage line.
Shaping and final rehabilitation of remaining overburden stockpiles and WRDs	
Rehabilitation of disturbed areas (possibly including soil, re-vegetation and profiling or contouring).	2. Possible contamination of surface water due to spillages of hydrocarbons during rehabilitation activities.
Mine closure and vegetating the project area close to its pre-mining state	3 The landscape will not be as pre-mining state, but the reduction in catchment area will be restored as well as the naturalised flow.

2.2.1. Impact Description: Sedimentation and siltation of nearby watercourses (Interaction 1)

Sedimentation and siltation of nearby watercourses is likely to occur during the demolition phase. Disturbance of soils through demolition and removal of infrastructure including the plant and WRD increases the rate of soil erosion leading to sedimentation and siltation of the nearby drainage lines.

2.2.2. Impact Description: Sedimentation and siltation of nearby watercourses (Interaction 2)

Surface water contamination due to hydrocarbon waste spillages. Spillages of hydrocarbons (oils, fuels, and grease) by vehicles and machinery used during the demolition and transportation of material from the decommissioned mine will contaminate surface water resources when washed into the drainage lines. Post-closure monitoring of water resources water quality is pivotal for a successful rehabilitation and closure plan.

2.2.3. Impact Description: Sedimentation and siltation of nearby watercourses (Interaction 3)

The drainage systems (where applicable) and landscapes will be rehabilitated close to their natural state before the mining activities. The impact rating was based on comparing the post-closure conditions with the pre-mining conditions.

2.2.4. Impact Rating

The following tables (Table 2-6 to Table 2-8) rate the impacts of the decommissioning phase:

Table 2-6: The Potential Impacts of Demolition and Removal of Infrastructure

Dimension	Rating	Motivation	Significance
Activity and Interaction: Demolition and removal of infrastructure			
Impact Description: Sedimentation and siltation of the nearby drainage line.			
Prior to Mitigation/Management			
Duration	3	Medium term (1-5 years). The impact will occur during the demolition phase	-18 Negligible (Negative)
Extent	1	Limited to isolated parts of the project site.	
Intensity	2	Minor natural impacts which are mostly replaceable. Damages (if any) can be rehabilitated.	
Probability	3	There is a possibility that the impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
• Limit soil disturbances to relevant areas during demolition. Movement of all demolition or any other heavy vehicles should be limited to the area of demolition and use of existing roads should be encouraged; • Demolition should be undertaken during the dry winter period to reduce sedimentation in the proximal watercourses since there will be minimal to no occurrence of rainfall during this period; • Install silt fences, erosion blankets prior to soil stabilisation on steep surfaces to reduce chances of erosion and further ensure that there is enough vegetation around the watercourses (drainage line); • Ensure that waste stockpiles are frequently collected and away from watercourses (drainage line); and • Monitoring of water quality should continue to take place post-mining activities.			
Post-Mitigation			
Duration	4	Medium term (1-5 years). The impact will occur during the demolition phase	-10 Negligible (Negative)
Extent	1	Limited to isolated parts of the project site.	

Dimension	Rating	Motivation	Significance
Intensity	1	With mitigations in place, it is envisaged that there will be minor to no impact on the environment.	
Probability	2	With mitigations in place the possibility of the impact happening is very low.	
Nature	Negative		

Table 2-7: The Potential Impacts of Spillages and Leakages from Vehicles and Machinery During the Demolition of Infrastructure

Dimension	Rating	Motivation	Significance
Activity and Interaction: Spillages and leakages from vehicles and machinery during the demolition of infrastructure.			
Impact Description: Contamination of water resources.			
Prior to Mitigation/Management			
Duration	3	Medium term (1-5 years). The impact will occur during the demolition phase	-18 Negligible (Negative)
Extent	1	Limited to isolated parts of the project site.	
Intensity	2	Minor natural impacts which are mostly replaceable. Damages (if any) can be rehabilitated.	
Probability	3	There is a possibility that the impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
• All waste from the demolition process should be taken off-site as soon as possible to avoid any demolition debris which may cause suspended solids during a heavy rainfall event; • The demolition of chemical storages or facilities should be carefully handled by suitable professional companies to avoid spillages; and • Monitoring of water quality in the canal should continue to take place post-mining activities. • Demolition should be undertaken during the dry winter period; • Washing and servicing of vehicles and machinery should only be undertaken at designated, appropriately designed areas; and • Monitoring of water quality should continue to take place post-mining activities.			
Post-Mitigation			

Dimension	Rating	Motivation	Significance
Duration	4	Medium term (1-5 years). The impact will occur during the demolition phase	-10 Negligible (Negative)
Extent	1	Limited to isolated parts of the project site.	
Intensity	1	With mitigations in place, it is envisaged that there will be minor to no impact on the environment.	
Probability	2	With mitigations in place the possibility of the impact happening is very low.	
Nature	Negative		

Table 2-8: Impact Significance Rating for Improvement in Drainage after Rehabilitation

Dimension	Rating	Motivation	Significance
Activity and Interaction: Rehabilitation including reprofiling of channel lining and landscape close its pre-mining state			
Impact Description: The reduction in catchment area will be restored as well as the naturalised flows to the environment.			
Prior to Mitigation/Management			
Duration	5	The impact will likely occur during the operational phase. Impact will cease after operation	-21 Negligible (Negative)
Extent	1	Very limited. Limited to isolated parts of the project site.	
Intensity	1	Limited damage to minimal area. The catchment area is already disturbed.	
Probability	3	There is a possibility that the impact will occur.	
Nature	Negative		
Mitigation/Management Actions			
• Allow the rainfall/runoff water will flow freely into the environment.			
Post-Mitigation			
Duration	3	The impact will be average, but it will have on-going benefits to the environment	5 Negligible (Positive)
Extent	1	Some environmental benefits felt by very few of the population.	
Intensity	1	Some environmental benefits that will improve the local bio-aquatic environment.	

Dimension	Rating	Motivation	Significance
Probability	1	The impact will be average, but it will have on-going benefits to the environment.	
Nature	Positive		

3. Conclusions and Recommendations

- The objective of this memo was to investigate how the plant infrastructure and surrounding upgrade could be affected by the surface water runoff from the upstream catchment and to provide the potential impact (pre and post mitigations) of the plant on the water resources;
- In addition to the proposed stormwater infrastructure that was provided by the Client, DWE proposed an additional berm along the northern portion to divert clean water away from the plant;
- The surface water impact assessment of the mine indicated that the mine will most likely have minor impacts on the hydrology of the area and that the mitigations would minimise these small impacts even further;
- The identified potential surface water/hydrological impacts that could emanate from the project and its associated activities include:
  - Siltation and sedimentation of the nearby drainage line; and
  - Contamination of surface water resources due to hydrocarbon leakages from moving vehicles; and
- The following is recommended to manage and mitigate identified surface water impacts:
  - The stormwater infrastructure (e.g., berms and silt-fence) should be well maintained;
  - Where applicable, berms should be vegetated to minimise or prevent soil erosion;
  - All operational vehicles must be inspected and maintained (on hardstanding surfaces only) regularly and stored/parked in designated areas equipped with drainage infrastructure to divert that runoff to storage on-site;
  - All mining personnel should be taught and trained to handle hazardous chemical waste to minimise spillages.
  - The use of spill kits is highly recommended and all storage facilities should be bunded; and
  - Water quality monitoring should continue to quickly detect pollution sources in order to implement mitigation measures at source before pollutants spread to other areas;

It can be concluded that if AfriTin is compliant with the various regulations guiding the management and protection of water resources and effectively implements an effective (undertaken by a separate company), its impact on the local and regional hydrology should be negligible.

Regards,

Ofentse Mokonoto	Kevin Bursey
Hydrologist	*Principal Hydrologist*

Appendix A: Impact/risk assessment

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in **Table 3-3**. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure(s) in this EIA/EMP Report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in **Table 3-3**, which is extracted from **Table 3-1**. The description of the significance ratings is discussed in **Table 3-3**.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 3-1: Impact Assessment Parameter Ratings

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	*Positive Impacts (Type of Impact = +1)*			
7	Very significant impact on the environment. Irreparable and irreplaceable damage to highly valued species, habitat or ecosystem. Persistent severe damage. Irreparable and irreplaceable damage to highly valued items of high cultural significance or complete breakdown of social order.	Noticeable, on-going social and environmental benefits which have improved the livelihoods and living standards of the local community in general and the environmental features.	International The effect will occur across international borders.	Permanent: No Mitigation The impact will remain long after the life of the Project. The impacts are irreversible.	Certain/Definite. There are sound scientific reasons to expect that the impact will definitely occur.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
6	Significant impact on highly valued species, habitat or ecosystem. Significant management and rehabilitation measures required to prevent irreplaceable impacts. Irreparable damage to highly valued items of cultural significance or breakdown of social order.	Great improvement to livelihoods and living standards of a large percentage of population, as well as significant increase in the quality of the receiving environment.	National Will affect the entire country.	Beyond Project Life The impact will remain for some time after the life of a Project.	Almost certain/Highly probable It is most likely that the impact will occur.
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread positive benefits to local communities which improves livelihoods, as well as a positive improvement to the receiving environment.	Province/ Region Will affect the entire province or region.	Project Life The impact will cease after the operational life span of the Project.	Likely The impact may occur.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
4	Serious medium term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense social benefits to some people. Average to intense environmental enhancements.	<u>Municipal Area</u> Will affect the whole municipal area.	<u>Long term</u> 6-15 years to reverse impacts.	<u>Probable</u> Has occurred here or elsewhere and could therefore occur.
3	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some.	<u>Local</u> Extending across the site and to nearby settlements.	<u>Medium term</u> 1-5 years to reverse impacts.	<u>Unlikely</u> Has not happened yet but could happen once in the lifetime of the Project, therefore there is a possibility that the impact will occur.
2	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by very few of population.	<u>Limited</u> Limited to the site and its immediate surroundings.	<u>Short term</u> Less than 1 year to completely reverse the impact.	<u>Rare/improbable</u> Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
1	Limited damage to minimal area of low significance that will have no impact on the environment. No irreplaceable loss of a significant aspect to the environment. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level social and environmental benefits felt by very few of the population.	<u>Very limited</u> Limited to specific isolated parts of the site.	<u>Immediate</u> Less than 1 month to completely reverse the impact.	<u>Highly unlikely/None</u> Expected never to happen.

Table 3-2: Probability/Consequence Matrix

Probability		Significance																																					
	7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
	6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
	5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
	4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
	3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
	2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
	1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		-21	**-20**	**-19**	**-18**	**-17**	**-16**	**-15**	**-14**	**-13**	**-12**	**-11**	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Consequence																																							

Table 3-3: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and/or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and/or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and/or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and/or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and/or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and/or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

BASELINE STUDY: VERTEBRATE FAUNA AND FLORA ASSOCIATED WITH THE UIS TIN MINING COMPANY: DRY & WET SEASON OBSERVATIONS – UIS AREA

SPECIALIST CONTRIBUTION:

Prepared by:

Peter L Cunningham

Environment and Wildlife Consulting Namibia

P. O. Box 417
Karasburg
Namibia
Mobile: +264 81-3004080
E-mail: pckkwrc@yahoo.co.uk

Prepared for:

Mr Lester Harker & Ms Jessica Bezuidenhout

Environmental Compliance Consultancy

Windhoek
Namibia
Mobile: +264 81-2627872
www.enviroconsultants.co.za
E-mail: lester@eccenvironmental.com & jessica@eccenvironmental.com

CONTENTS

Vertebrate fauna and flora associated with the Uis Tin Mining Company (ML134): dry & wet season observations – Uis area

1 Introduction

A desktop study (i.e. literature review) was conducted between 18 and 21 September 2021 on the vertebrate fauna (e.g. reptiles, amphibians, mammals and birds) and flora (larger trees and shrubs and grasses) expected to occur in the general Uis area. This was supported by a rapid site assessment between 13 and 16 September 2021 to determine actual vertebrate fauna and flora (including unique habitats) at the proposed development areas (i.e. dry season study) and 7 and 10 February 2022 (i.e. wet season study). The aim of this study is to determine the vertebrate fauna and flora, especially unique species and important habitats, located within the ML134 and which might be affected by further mining/exploration developments and compare seasonal differences in species composition (See Figure 1).

This literature review was to determine the actual as well as potential vertebrate fauna and flora associated with the general Uis (ML134) area and commonly referred to as the Semi-desert Savannah and Transition Zone [Escarpment area] (Giess 1971, Van der Merwe 1983) or the areas referred to by Mendelsohn *et al.* (2002) as the Western-Central Escarpment and Inselbergs and/or Western Highlands (the Uis area is located on the boundary of these two vegetation types). This semi-desert and savannah transition zone as referred to by Giess (1971) is typified by shrubs ("fodder bushes") such as *Blepharis pruinosa*, *Leucosphaera bainesii* and *Monechma genistifolia*. Larger woody species such as *Acacia erioloba* are confined to the drainage lines. The Uis area is characterised by *A. senegal* shrubs while *Cyphostemma currorii* and *C. bainesii* also occur in this region. The trees common in the area are *Commiphora glaucescens*, *C. virgata* and *C. dinteri* as well as *Boscia albitrunca* and *B. foetida*. The grass cover is sparse and consists of the climax grasses *Stipagrostis obtusa* and *S. uniplumis* (Giess 1971).

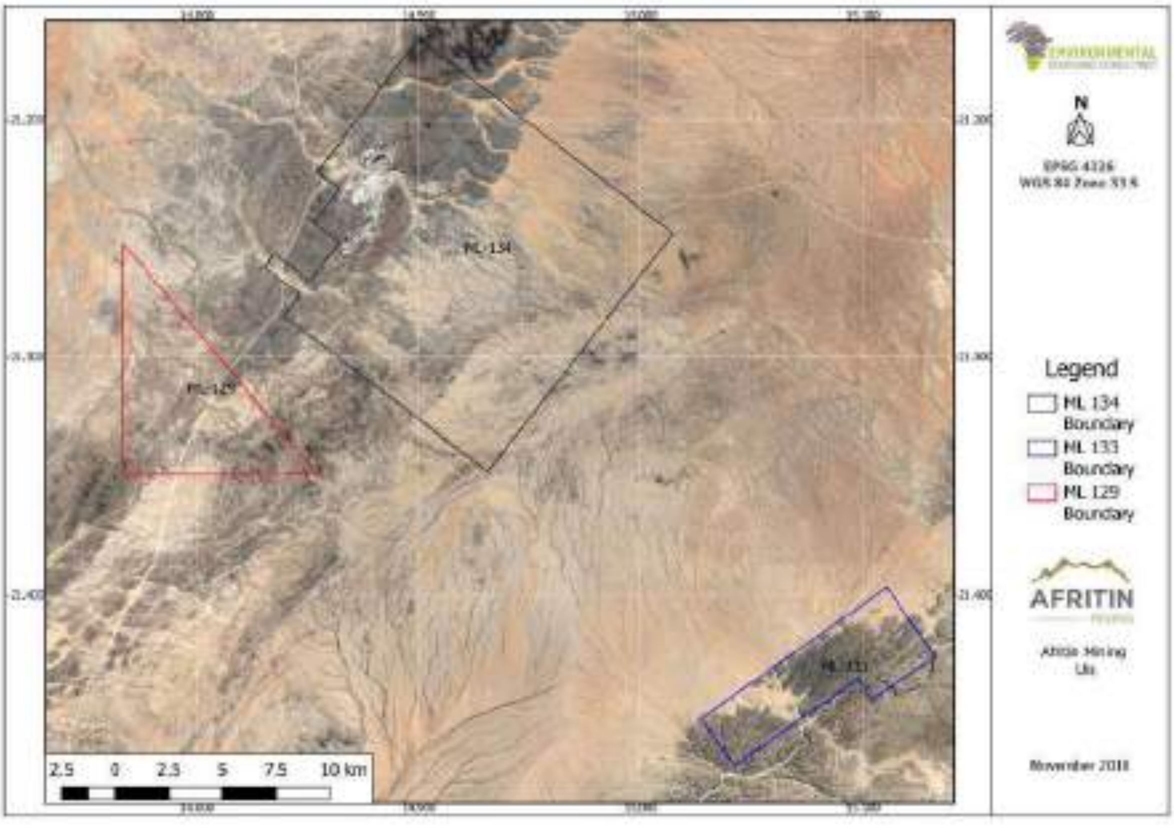

Figure 1. The ML134 is located around Uis (mainly to the southeast of Uis) in the Erongo Region.

The Namib Desert biome; located immediately to the west of Uis, is well protected with parks in this biome making up 69% of the network compared to only 7% of the Savannah biome being formally protected and the Mountain Savannah area being wholly under protected (Barnard 1998). Sites of special ecological importance in the general Uis area include the Brandberg, located 20-30km to the north/northwest of Uis (i.e. high endemicity of plants, reptiles and insects; major rock art sites and area threatened by tourism pressure) and the granite domes (Uis, but also in the general Karibib and Omaruru districts) which are high in biotic richness and endemism (Curtis and Barnard 1998).

The Uis area in general is regarded as "moderate" in overall (all terrestrial species) diversity and overall terrestrial endemism in the area on the other hand is "high" (Mendelsohn *et al.* 2002). The overall diversity and abundance of large herbivorous mammals (big game) is viewed as "moderate" with 3-4 species expected – e.g. gemsbok, mountain zebra and springbok – while overall diversity and density of large carnivorous mammals (large predators) is viewed as "moderate" with 4 species expected – e.g. leopard, cheetah, spotted and brown hyena (Mendelsohn *et al.* 2002).

The generally Uis area is viewed as an area of importance for local endemic plant species, especially the Brandberg and Erongo Mountains with >35 (Brandberg) and between 26-35 endemic species (Erongo Mountains) (Mendelsohn *et al.* 2002). The overall plant diversity (all species) in the general Uis area is estimated at between 150-299 species and the Brandberg and Erongo Mountain areas between 400-499 species (Mendelsohn *et al.* 2002). These estimates are limited to "higher" plants as information regarding "lower" plants is sparse. The greatest variants affecting the diversity of plants are habitat and climate with the highest plant diversity generally associated with high rainfall areas. Pockets of high diversity are found throughout Namibia in "unique" habitat – often transition zones – e.g. mountains, inselbergs, etc. Plant endemism, other than the Brandberg and Erongo Mountains, is viewed as "medium to high" – with between 6-25 endemics expected from the general area (Mendelsohn *et al.* 2002). Furthermore, Mendelsohn *et al.* (2002) views the overall plant production as low in the general Uis area and high in the Erongo Mountains, the availability of hardwoods as low and the grazing and browse as low to average in the general area. Bush thickening (encroachment) is viewed as problematic between to the south of Uis – i.e. Karibib and Omaruru with *Acacia reficiens* (red-bark Acacia) the dominant problem species (Bester 1996, Cunningham 1998, Mendelsohn *et al.* 2002).

The carrying capacity for the general area is 0-20kg/ha (Mendelsohn *et al.* 2002) or 10-15LAU/ha (van der Merwe 1983) and the risk of farming is viewed as high. Goat and sheep farming is the dominant farming activity in the Uis area with densities of 1-10/km^2 (Mendelsohn *et al.* 2002). There are numerous existing tourism ventures in the area with the tourism potential viewed as relatively high (Mendelsohn *et al.* 2002).

The area falls within the Tsiseb Communal Conservancy (7,913km^2) with the major wildlife resources viewed as elephant, black rhino, leopard, cheetah, mountain zebra, kudu, gemsbok, ostrich, springbok, steenbok, black-backed jackal and klipspringer. However, most of these species are not expected to occur in/around Uis – i.e. the general ML134 area – due to anthropogenic influences. The main source of income of the Tsiseb Communal Conservancy is tourism. The closest Freehold (i.e. commercial) Conservancy is Okawi, east of Karibib (MEFT/NACSO 2021, Mendelsohn *et al.* 2002, NACSO 2010, See: www.nacso.org.na).

It is estimated that at least 57 species of reptile, 8 amphibian, 87 mammal, 190 birds, 104 larger trees and shrubs and up to 80 grass species occur in the general/immediate Uis area of which a high proportion are endemics (e.g. reptiles – 49.1%).

2 Methods

2.1 Literature review

A comprehensive and intensive literature review (i.e. desktop study) regarding the reptiles, amphibians, mammals, birds, larger trees and shrubs (>1m in height) and grasses that could potentially occur in the general Uis area (i.e. within the ML134 area) was conducted using as many references as manageable.

A list of the references consulted can be viewed in the Reference section (Page 74).

2.2 Field Survey

Field work was conducted during September 2021 and February 2022 to cover dry and wet season species composition changes.

Vertebrate fauna
According to the original Terms of Reference (ToR), a rapid fieldwork assessment to determine the actual faunal diversity would include the following:

- Small mammal transects to determine small mammal diversity in the area
- Assess larger mammal presence in the area
- Reptile and amphibian transects to determine reptile and amphibian diversity in the area
- Bird transects to determine avian diversity in the area
- Tree/shrub transects to determine diversity in the area
- Grass transects to determine diversity in the area

Reptiles
Diurnal and nocturnal reptile transects were conducted along various transects throughout the proposed development area and were not conducted in rigid straight lines, but focused on the habitat viewed as most suitable for reptiles. Reptiles observed were either caught by hand or by using an active capture technique called 'reptile noosing' where an extendable fishing rod was fitted with a soft thread noose, positioned over the unsuspecting head of an individual and pulled tight. This technique does not result in the death or injury of the caught specimen. Species caught were identified *in situ*, photographed and released unharmed at the point of capture.

Amphibians
Amphibians were searched for in areas deemed suitable habitat – e.g. drainage lines, dams, etc. – with species encountered identified *in situ*.

Mammals
Small mammal trapping was conducted by active trapping using collapsible aluminium Sherman traps baited with peanut butter and oats. Traps were set at 5 sites throughout the area with 10 traps placed 10m apart for 2 nights (i.e. potential maximum of 50 captures) in habitats viewed as potentially suitable for small mammals in the ML134 area.

Assessing larger mammals from the area was conducted by traversing the area on foot and included actual sightings, tracks, scats and other signs – e.g. burrows, scrapes, carcasses, etc.

Birds
Bird transects (variable lengths, directions and times) were conducted on foot and by vehicle following permissible tracks throughout the area (when in vehicle) during daylight hours using binoculars to identify and confirm species.

Flora
According to the original ToR, fieldwork to determine the actual floral diversity was to include the following:

- Trees and shrubs – species composition
- Grasses – species composition
- Other species

Trees and shrubs
All the trees and shrubs encountered in the proposed development areas were identified whilst conducting the fieldwork in the area – i.e. identification was not only limited to transect only. Trees and shrubs species composition was quantified. The transect lengths varied according to the terrain.

Grasses
All the grasses encountered in the proposed development areas were identified whilst conducting the fieldwork in the area – i.e. identification was not only limited to transect only. Grass species composition was quantified. The transect lengths varied according to the terrain.

Other species
Other species – i.e. bulbs, herbs, etc. – were also identified whenever encountered although the general area was very dry during September 2021 with the Uis area having experienced severe drought conditions reflected in the overall vegetation diversity, especially bulbs and herb, etc. However, rainfall occurred during mid/late January 2022 throughout the general Uis area and this was reflected in the vegetation emergence and growth as observed during early February 2022 (this report).

3 Results

3.1 Reptile Diversity

Reptile diversity known and/or expected to occur in the Uis area, including species confirmed during the fieldwork conducted, is presented in Table 1.

Approximately 261 species of reptiles are known or expected to occur in Namibia thus supporting approximately 30% of the continents species diversity (Griffin 1998a). At least 22% or 55 species of Namibian lizards are classified as endemic. The occurrence of reptiles of “conservation concern” includes about 67% of Namibian reptiles (Griffin 1998a). Emergency grazing and large scale mineral extraction in critical habitats are some of the biggest problems facing reptiles in Namibia (Griffin 1998a). The overall reptile diversity and endemism in the general Uis area is estimated at between 51-70 species and 25-28 species, respectively (Mendelsohn *et al.* 2002). Griffin (1998a) presents figures of between 41-50 and 9-10 for endemic lizards and snakes, respectively, from the general area, while the closest protected area, the Skeleton Coast Park, has an estimated 77 species. There is currently no data for the !Dorob National Park.

At least 57 species of reptiles are expected to occur in the Uis area with 28 species being endemic – i.e. 49.1% endemic. These consist of at least 22 snakes (2 thread snake, 2 python, 1 burrowing snake and 17 typical snakes), 11 of which are endemic (50%) to

Table 1. Reptile diversity expected (literature study) and confirmed during the fieldwork ($\sqrt{}^{D}$ = Dry season and $\sqrt{}^{W}$ = Wet season), including a published record from Cunningham and van der Waal (2010) (√#), from the general Uis (ML134) area.

Species: Scientific name	Species: Common name	Species confirmed	Namibian conservation and legal status	International status		
				SARDB	IUCN	CITES
TORTOISES AND TERRAPINS						
Stigmochelys pardalis	Leopard Tortoise		Vulnerable; Peripheral; Protected Game		LC	C2
SNAKES						
Thread Snakes						
Namibiana (Leptotyphlops) occidentalis	Western Thread Snake		Endemic; Secure	P	LC	
Namibiana (Leptotyphlops) labialis	Damara Thread Snake		Endemic; Secure		LC	
Pythons						
Python anchietae	Dwarf Python		Endemic; Insufficiently known; Protected game		LC	C2
Python natalensis	Southern African Python		Vulnerable; Peripheral; Protected Game	V		C2
Burrowing Snakes						
Xenocalamus bicolour bicolor	Bicoloured Quill-snouted Snake		Secure			
Typical Snakes						
Boaedon (Lamprophis) fuliginosus	Brown House Snake					
Lycophidion namibianum	Namibian Wolf Snake		Endemic; Secure		LC	
Pseudaspis cana	Mole Snake		Secure			
Pythonodipsas carinata	Western Keeled Snake		Endemic; Secure		LC	
Prosymna frontalis	South-western Shovel-snout		Endemic; Secure	P	LC	
Dipsina multimaculata	Dwarf Beaked Snake		Endemic; Secure			
Psammophis trigrammus	Western Sand Snake		Endemic; Secure		LC	
Psammophis notostictus	Karoo Sand Snake		Secure			
Psammophis leightoni namibensis	Namib Sand Snake		Secure		LC	
Psammophis brevirostris leopardinus	Leopard Grass Snake		Endemic; Secure			
Dasypeltis scabra	Common/Rhombic Egg Eater		Secure		LC	
Aspidelaps lubricus infuscatus	Coral Snake		Secure			
Elapsoidea sunderwallii fitzsimonsi	Sundevall's Garter Snake		Endemic; Secure			
Naja annulifera anchietae	Snouted Cobra		Secure		LC	
Naya nigricincta	Black-necked Spitting Cobra	√#	Endemic; Secure			
Bitis arietans	Puff Adder		Secure			
Bitis caudalis	Horned Adder	$\sqrt{}^{D}$;√#	Secure			
WORM LIZARDS						
Zygaspis quadrifrons	Kalahari Round-headed Worm Lizard		Secure			

LIZARDS						
Skinks						
Trachylepis acutilabris	Wedge-snouted Skink	√[D,W]	Secure		LC	
Trachylepis capensis	Cape Skink		Secure			
Trachylepis hoeschi	Hoesch's Skink		Endemic; Secure		LC	
Trachylepis occidentalis	Western Three-striped Skink		Secure			
Trachylepis spilogaster	Kalahari Tree Skink	√[D,W]	Endemic; Secure			
Trachylepis striata wahlbergi	Striped Skink		Secure			
Trachylepis sulcata	Western Rock Skink	√[D]	Secure			
Trachylepis variegata variegata	Variegated Skink		Secure			
Old World Lizards						
Meroles suborbitalis	Spotted Desert Lizard		Secure		LC	
Pedioplanis breviceps	Short-headed Sand Lizard		Endemic; Secure		LC	
Pedioplanis namaquensis	Namaqua Sand Lizard	√[D,W]	Secure			
Pedioplanis undata	Western Sand Lizard	√[D,W]	Endemic; Secure		LC	
Pedioplanis gaerdesi	Kaokoveld Sand Lizard		Endemic; Secure		LC	
Plated Lizards						
Cordylosaurus subtessellatus	Dwarf Plated Lizard		Endemic; Secure		LC	
Monitors						
Varanus albigularis	Rock or White-throated Monitor	√[W]	Vulnerable; Peripheral; Protected Game	S to V		C2
Agamas						
Agama achuleata	Ground Agama	√[D]	Secure			
Agama anchietae	Anchietae's Agama	√[W]	Secure		LC	
Agama planiceps	Namibian Rock Agama		Endemic; Secure		LC	
Chameleons						
Chamaeleo namaquensis	Namaqua Chameleon		Secure		LC	C2
Geckos						
Afroedura africana africana	African Flat Gecko		Endemic; Insufficiently known; Rare		LC	
Chondrodactylus angulifer namibensis	Giant Ground Gecko		Endemic; Secure		LC	
Lygodactylus bradfieldi	Bradfield's Dwarf Gecko	√[D]	Endemic; Secure			
Pachydactylus bicolour	Velvety Thick-toed Gecko		Endemic; Secure			
Pachydactylus fasciatus	Banded Thick-toed Gecko		Endemic; Secure		LC	
Pachydactylus kochii	Koch's Thick-toed Gecko		Endemic; Secure		LC	
Pachydactylus turneri	Turner's Thick-toed Gecko	√[W]	Secure			
Pachydactylus mariquensis latirostris	Marico Thick-toed Gecko		Endemic; Secure		LC	
Pachydactylus oreophilus	Kaokoveld Thick-toed Gecko		Endemic; Secure		LC	
Pachydactylus punctatus	Speckled Thick-toed Gecko		Secure			

Pachydactylus rugosus	Rough Thick-toed Gecko		Endemic; Secure	LC
Pachydactylus weberi	Weber's Thick-toed Gecko		Secure	LC
Ptenopus garrulus maculatus	Common Barking Gecko	√[D,W]	Secure	LC
Rhoptropus boultoni	Boulton's Namib Day Gecko	√[D,W]	Endemic; Secure	LC

Namibian conservation and legal status according to the Nature Conservation Ordinance No. 4 of 1975
Endemic – includes Southern African Status (Branch 1998)
SARDB (2004): S to V – Safe to Vulnerable; V – Vulnerable; P – Peripheral
IUCN (2021): LC – Least Concern [All other species not yet assessed]
CITES: CITES Appendix 2 species

Source for literature review: Alexander and Marais (2007), Branch (1998), Branch (2008), Boycott and Bourquin (2000), Broadley (1983), Buys and Buys (1983), Cunningham (2006), Cunningham and van der Waal (2010), Griffin (2003), Hebbard (n.d.), IUCN (2021), Marais (1992), SARDB (2004), Tolley and Burger (2007)

Namibia, 1 tortoise, 34 lizards (1 worm lizard, 8 skinks, 5 Old World lizards, 1 plated lizard, 1 monitor lizard, 3 agamas, 1 chameleon and 14 geckos), 17 (50%) of which are endemic to Namibia. Skink's (8 species) and gecko's (14 species) are the most numerous lizards expected from the general area. Namibia with approximately 129 species of lizards (Lacertilia) has one of the continents richest lizard fauna (Griffin 1998a). Geckos have the highest occurrence of endemics in the general area with 13 of the 17 species (71.4%) expected and/or known to occur in the area, being endemic to Namibia.

According to the Namibian legislation 1 species is viewed as rare (*Afroedura africana africana*), 3 species as vulnerable (*Stigmochelys pardalis*, *Python natalensis*, *Varanus albigularis*), 4 species as protected game, 2 species insufficiently known and 3 species as peripheral. The IUCN (2021) classifies 31 species as least concern although not all the reptiles have yet been assessed by the IUCN Red List. The SARDB (2004) classifies 1 species as vulnerable, 1 species as safe to vulnerable and 2 species as peripheral while CITES lists 5 species under Appendix 2 and 1 species under Appendix 3. Due to the fact that reptiles are an understudied group of animals, especially in Namibia, it is expected that more species may be located in the general area than presented above.

During the fieldwork a total of 14 species (10 dry season and 9 wet season – some species observed in both seasons) were confirmed from the ML 134 area which included 2 snakes, 3 skinks, 2 Old World lizards, 1 monitor, 2 agamas and 4 geckos (Figures 2-13) (This includes Cunningham and van der Waal 2010 – See Table 1).

Figure 2. Horned adder (*Bitis caudalis*) encountered in rocky terrain.

Figure 3. Wedge-snouted skink (*Trachylepis acutilabris*) was the most commonly encountered reptile throughout the area.

Figure 4. Kalahari tree skink (*Trachylepis spilogaster*) is a tame and frequently observed species associated with trees and rocky areas.

Figure 5. Western rock skinks (*Trachylepis sulcata*) are very nervous and associated with rocky areas.

Figure 6. Namaqua sand lizard (*Pedioplanis namaquensis*) is a small and fast moving lizard associated with sandy terrain.

Figure 7. Western sand lizard (*Pedioplanis undata*) is common throughout the area and associated with rocky and gravel terrain.

Figure 8. Ground agama (*Agama achuleata*) hiding in a rocky crevasse.

Figure 9. Boulton's Namib day gecko (*Rhoptropus boultoni*) was frequently observed in rocky terrain, usually with large boulders with suitable hiding places.

Figure 10. Rock or white-throated monitor (*Varanus albigularis*) is listed as vulnerable; peripheral; protected game under the Namibian legislation and as CITES Appendix 2 species.

Figure 11. Anchietae's agama (*Agama anchietae*) observed basking in gravel plain habitat.

Figure 12. Turner's thick-toed gecko (*Pachydactylus turneri*) observed in rocky terrain, usually with large boulders with suitable hiding places.

Figure 13. Common barking gecko (*Ptenopus garrulus maculatus*) was heard and observed in sandy/gravel plain areas throughout the ML134 area.

Nocturnal fieldwork was conducted for 1 hour over 5 nights (3 nights dry season and 2 nights wet season), but due to the overall dry conditions and cold ambient temperatures (<16°C most reptiles are inactive) only 1 species – *Ptenopus garrulus* – was observed during the dry season and 2 species – *Pachydactylus turneri* and *Ptenopus garrulous* – were observed during the wet season (See Figures 12-13).

The most important species expected to occur in the general area (See Table 1) are viewed as the tortoise *Stigmochelys pardalis*; pythons – *P. anchietae* and *P. natalensis*; Namibian wolf snake (*Lycophidion namibianum*) – *Varanus albigularis* and some of the endemic and little known gecko species – e.g. *Pachydactylus* species. Tortoises, snakes and monitor lizards are routinely killed for food or as perceived threats. Another important species is the "rare" – i.e. *Afroedura africana africana* – although very little is known about this species.
The most important species confirmed from the general area is the rock/white-throated monitor (*Varanus albigularis*) which is listed as vulnerable; peripheral; protected game under the Namibian legislation and as CITES Appendix 2 species (See Table 1 and Figure 10). *Varanus albigularis* eggs (hatched) were also observed in soil around dead *Commiphora* species on a number of occasions indicating the potential important connection of this reptile and *Commiphora* species in the area (Figure 14).

Figure 14. *Varanus albigularis* eggs (hatched) observed in soil at the base of dead *Commiphora* species in rocky terrain in the area.

The ML134 area is heavily impacted due to its close proximity to Uis and associated anthropogenic influences as well as current/past mining and informal mining/prospecting activities with none of the unique reptiles expected to be exclusively associated with this area. The proposed mitigations – See Section 4 – are expected to minimise the overall effect on reptiles potentially occurring in the area.

3.2 Amphibian Diversity

Amphibian diversity known and/or expected to occur in the Uis area, including species confirmed during the fieldwork conducted, is presented in Table 2.

Amphibians are declining throughout the world due to various factors of which much has been ascribed to habitat destruction. Basic species lists for various habitats are not always available with Namibia being no exception in this regard while the basic ecology of most species is also unknown. Approximately 4,000 species of amphibians are known worldwide with just over 200 species known from southern Africa and at least 57 species expected to occur in Namibia. Griffin (1998b) puts this figure at 50 recorded species and a final species richness of approximately 65 species, 6 of which are endemic to Namibia. This "low" number of amphibians from Namibia is not only as a result of the generally marginal desert habitat, but also due to Namibia being under studied and under collected. Most amphibians require water to breed and are therefore associated with the permanent water bodies, mainly in northeast Namibia.

According to Mendelsohn *et al.* (2002), the overall frog diversity in the general Uis area is estimated at between 4-7 species. Griffin (1998b) puts the species richness in the general area at 5-8 species, while Channing and Griffin (1993) expect at least 5 species from the general area. The closest protected area, the Skeleton Coast Park, has an estimated 10 species (Griffin 1998b). There is currently no data for the !Dorob National Park.

At least 8 species of amphibians are expected to occur in suitable habitat in the Uis area. The area is under represented, with 2 pygmy toads, 2 sand frogs, 1 species each for toad, rubber, puddle, and platanna known and/or expected (i.e. potentially could be found in the area) to occur in the area. Of these, 4 species are endemic (*Poyntonophrynus damaranus*, *Poyntonophrynus hoeschi*, *Phrynomantis annectens* and *Tomopterna damarensis*) (Griffin 1998b) of which 2 species is classified as "data deficient" (*Poyntonophrynus damaranus*,

Table 2. Amphibian diversity expected (literature study) and confirmed during the fieldwork ($\sqrt{}^{D}$ = Dry season and $\sqrt{}^{W}$ = Wet season) from the general Uis (ML134) area.

Species: Scientific name	Species: Common name	Species confirmed	Namibian conservation and legal status	International Status: IUCN
Toads				
Amietophrynus poweri	Western Olive Toad			LC
Pygmy Toads				
Poyntonophrynus damaranus	Damaraland Pygmy Toad		Endemic	DD
Poyntonophrynus hoeschi	Hoesch's Pygmy Toad		Endemic	LC
Rubber Frog				
Phrynomantis annectens	Marbled Rubber Frog		Endemic	LC
Puddle Frog				
Phrynobatrachus mababiensis	Dwarf Puddle Frog			LC
Sand Frogs				
Tomopterna damarensis	Damaraland Sand Frog		Endemic	DD
Tomopterna tandyi	Tandy's Sand Frog			LC
Platannas				
Xenopus laevis	Common Platanna			LC

Endemic – (Griffin 1998b)
IUCN (2021): DD – Data Deficient; LC – Least Concern

Source for literature review: Carruthers (2001), Channing (2001), Channing and Griffin (1993), Du Preez and Carruthers (2009), IUCN (2021), Passmore and Carruthers (1995), SARDB (2004)

Tomopterna damarensis) by the IUCN (2021) – i.e. high level (50%) of amphibians of conservation value (including endemism) from the general area.

During the fieldwork (dry and wet seasons) no species were confirmed from the ML 134 area as there area had experienced a prolonged drought and there was limited open surface water, including the Uis sewage works, encountered – See Table 2 (Figures 15-17).

Important species include the 4 endemics (*Poyntonophrynus damaranus*, *Poyntonophrynus hoeschi*, *Phrynomantis annectens* and *Tomopterna damarensis*) and especially the 2 species also classified as data deficient (*Poyntonophrynus damaranus*, *Tomopterna damarensis*) by the IUCN (2021).

Figure 15. Well vegetated ephemeral drainage lines, especially adjacent rocky areas with rock pools, could potentially serve as seasonal amphibian habitat throughout the general area.

Figure 16. An old well, now dry, attests to wetter times as well as potential amphibian habitat.

Figure 17. A few borrow pits along the Omaruru-Uis gravel road with water after the January rains are potential amphibian habitat, albeit temporary of nature.

The ML134 area is heavily impacted due to its close proximity to Uis and associated anthropogenic influences as well as current/past mining and informal mining/prospecting activities with none of the unique amphibian expected to be exclusively associated with this area. However, the potential presence of the 2 species classified as data deficient (*Poyntonophrynus damaranus*, *Tomopterna damarensis*) by the IUCN (2021), is viewed as important and potential habitats should be identified and avoided to protect these little known species (IUCN 2021). The proposed mitigations – See Section 4 – are expected to minimise the overall effect on amphibians potentially occurring in the area.

3.3 Mammal Diversity

Mammal diversity known and/or expected to occur in the Uis area, including species confirmed during the fieldwork conducted, is presented in Table 3.

Namibia is well endowed with mammal diversity with at least 250 species occurring in the country. These include the well known big and hairy as well as a legion of smaller and lesser-known species. Currently 14 mammal species are considered endemic to Namibia of which 11 species are rodents and small carnivores of which very little is known. Most endemic mammals are associated with the Namib and escarpment with 60% of these rock-dwelling (Griffin 1998c). According to Griffin (1998c) the endemic mammal fauna is best characterized by the endemic rodent family *Petromuridae* (Dassie rat) and the rodent genera *Gerbillurus* and *Petromyscus*.

Overall terrestrial diversity and endemism – all species – is classified as "moderate" and "high" respectively in the general Uis area (Mendelsohn *et al.* 2002). The overall diversity and abundance of large herbivorous mammals (big game) is viewed as "moderate" with 3-4 species expected – e.g. gemsbok, mountain zebra and springbok – while overall diversity and density of large carnivorous mammals (large predators) is viewed as "moderate" with 4 species expected – e.g. leopard, cheetah, spotted and brown hyena (Mendelsohn *et al.* 2002). The overall mammal diversity in the general Uis area is estimated at between 61-75 species with 7-8 species being endemic to the area (Mendelsohn *et al.* 2002). Griffin (1998c) puts the species richness distribution of endemic mammals between 7-8 species in the general area, while the closest protected areas, the Skeleton Coast Park, at 87 species. There is currently no data for the !Dorob National Park.

Table 3. Mammal diversity expected (literature study) and confirmed during the fieldwork (√^{D} = Dry season and √^{W} = Wet season) from the general Uis (ML134) area.

Species: Scientific name	Species: Common name	Species confirmed	Namibian conservation and legal status	International status		
				SARDB	IUCN	CITES
CITESElephant Shrews						
Macroscelides proboscideus	Round-eared Elephant-shrew	√^{D}	Endemic; Secure			
Elephantulus rupestris	Western Rock Elephant-shrew	√^{D,W}	Secure			
Elephantulus intufi	Bushveld Elephant-shrew		Secure	DD		
Aardvark						
Orycteropus afer	Aardvark	√^{D,W}	Secure; Protected Game			
Shrews			Secure	DD		
Crocidura fuscomurina	Tiny Musk Shrew					
Crocidura cyanea	Reddish-grey Musk Shrew		Secure	DD		
Hyrax						
Procavia capensis	Rock Hyrax	√^{D}	Secure; Problem animal			
Bats						
Eidolon helvum	African Straw-coloured Fruit Bat		Secure (Migrant)	NT	NT	
Mops midas	Midas Free-tailed Bat		Secure			
Miniopterus natalensis	Natal Long-fingered Bat		Secure	NT		
Mimetillus thomasi	Thomas's Flat-headed Bat		Not listed			
Sauromys petrophilus	Flat-headed Free-tailed Bat		Secure			
Tadarida aegyptiaca	Egyptian Free-tailed Bat		Secure			
Neoromicia capensis	Cape Serotine Bat		Secure			
Neoromicia zuluensis	Zulu Serotine Bat		Secure			
Nycticeinops schlieffeni	Schleiffen's Twighlight Bat		Secure			
Pipistrellus rueppellii	Rüppell's Pipistrelle		Insufficiently known; Peripheral			
Pipistrellus rusticus	Rusty Pipistrelle		Not listed			
Cistugo seabrai	Namibian Wing-gland Bat		Endemic; Rare	V		
Eptesicus hottentotus	Long-tailed Serotine Bat		Secure			
Scotophilus dinganii	African Yellow Bat		Secure			
Nycteris thebaica	Egyptian Slit-faced Bat		Secure			
Rhinolophus fumigatus	Rüppell's Horseshoe Bat		Secure	NT		
Rhinolophus clivosus	Geoffroy's Horseshoe Bat		Secure	NT		
Rhinolophus darlingi	Darling's Horseshoe Bat		Secure	NT		
Rhinolophus denti	Dent's Horseshoe Bat		Secure	NT		
Rhinolophus hildebrandtii	Hildebrandt's Horseshoe Bat		Not listed			

Macronycteris (Hipposideros) commersoni	Commerson’s Roundleaf Bat		Secure		NT	
Hipposideros caffer	Sundevall’s Roundleaf Bat		Secure	DD		
*Macronycteris (Hipposideros) gigas**	Giant Leaf-nosed Bat		Not listed			
Macronycteris (Hipposideros) vittatus	Striped Leaf-nosed Bat		Not listed		NT	
Hares and Rabbits						
Lepus capensis	Cape Hare	√[D,W]	Secure			
Lepus saxatilis	Scrub Hare		Secure			
Pronolagus randensis	Jameson’s Red Rock Rabbit		Secure			
Rodents						
Porcupine						
Hystrix africaeaustralis	Cape Porcupine	√[D]	Secure			
Rats and Mice						
Petromys typicus	Dassie Rat	√[D,W]	Endemic; Secure	NT		
Pedetes capensis	Springhare		Secure			
Xerus inaurus	South African Ground Squirrel		Secure			
Xerus princeps	Damara Ground Squirrel	√[D,W]	Endemic	NT		
Graphiurus rupicola/platyops	Western Rock Dormouse		Endemic; Secure	DD		
Graphiurus murinus	Woodland Dormouse		Secure			
Rhabdomys pumilio	Four-striped Grass Mouse	√[W]	Secure			
Mus indutus	Desert Pygmy Mouse		Secure			
Mastomys natalensis	Natal Multimammate Mouse		Secure			
Mastomys coucha	Southern Multimammate Mouse		Secure			
Thallomys paedulcus	Acacia Rat		Secure			
Thallomys nigricauda	Black-tailed Tree Rat		Secure			
Aethomys chrysophilus	Red Veld Rat		Secure			
Micaelamys namaquensis	Namaqua Rock Mouse	√[D,W]	Secure			
Desmodillus auricularis	Cape Short-tailed Gerbil		Secure			
Gerbillurus paeba	Hairy-footed Gerbil		Secure			
Gerbillurus setzeri	Setzer’s Hairy-footed Gerbil		Endemic			
Tatera leucogaster	Bushveld Gerbil	√[D,W]	Secure	DD		
Saccostomus campestris	Pouched Mouse		Secure			
Malacothrix typica	Gerbil Mouse		Secure			
Petromyscus collinus	Pygmy Rock Mouse	√[D,W]	Endemic; Secure			
Mus musculus	House Mouse		Invasive alien			
Primates						
Galago moholi	South African Galago		Vulnerable; Protected Game			C2
Papio ursinus	Chacma Baboon		Secure; Problem animal			C2

Hedgehog						
Atelerix frontalis angolae	Southern African Hedgehog		Insufficiently Known; Rare; Protected Game	NT; R		
Carnivores						
Proteles cristatus	Aardwolf		Insufficiently known; (Vulnerable?) Peripheral			
Parahyaena (Hyaena) brunnea	Brown Hyena		Insufficiently known; (Vulnerable?) Peripheral	NT	NT	
Crocuta crocuta	Spotted Hyena		Secure?; Peripheral	NT		
Acinonyx jubatus	Cheetah		Vulnerable; Protected Game	V	V	C1
Panthera pardus	Leopard		Secure?; Peripheral; Protected Game		V	C1
Caracal caracal	Caracal		Secure; Problem Animal			C2
Felis silvestris	African Wild Cat		Vulnerable			C2
Genetta genetta	Small Spotted Genet		Secure			
Suricata suricatta marjoriae	Suricate	√[W]	Endemic; Secure			
Cynictis penicillata	Yellow Mongoose	√[D]	Secure			
Galerella sanguinea	Slender Mongoose		Secure			
Galerella flavescens (nigrata)	Kaokoland/Black Slender Mongoose		Endemic; Secure			
Otocyon megalotis	Bat-eared Fox		Vulnerable?; Peripheral			
Vulpes chama	Cape Fox		Vulnerable?			
Canis mesomelas	Black-backed Jackal	√[D,W]	Secure; Problem animal			
Mellivora capensis	Honey Badger/Ratel		Secure; Protected Game	NT		
Ictonyx striatus	Striped Polecat		Secure			
Equidae						
Equus zebra hartmannae	Hartmann's Mountain Zebra		Endemic; Secure; Specially Protected Game	E	V	C2
Suidae						
Phacochoerus africanus	Common Warthog		Secure; Huntable Game			
Antelopes						
Giraffa camelopardalis	Giraffe		Vulnerable; Peripheral; Specially Protected Game		V	
Tragelaphus strepsiceros	Greater Kudu		Secure; Huntable Game			
Oryx gazella	Gemsbok		Secure; Huntable game			
Sylvicapra grimmia	Common Duiker		Secure			
Antidorcas marsupialis	Springbok	√[D,W]	Secure; Huntable game			
Madoqua damarensis	Damara Dik-dik		Insufficiently Known; Protected Game			
Raphicerus campestris	Steenbok	√[D]	Secure; Protected Game			
Oreotragus oreotragus	Klipspringer		Secure; Specially Protected Game			

SARDB (2004): R – Rare, E – Endangered, V – Vulnerable, NT – Near Threatened, DD – Data Deficient
IUCN (2021): V – Vulnerable, NT – Near Threatened. All other species not listed are viewed as "Least Concern" by IUCN (2021)
CITES: CITES Appendix 1/2 species
*Monadjem *et al.* (2010)

Source for literature review: De Graaff (1981), Griffin and Coetzee (2005), Estes (1995), IUCN (2021), Joubert and Mostert (1975), Monadjem *et al.* (2010), SARDB (2004), Skinner and Smithers (1990), Skinner and Chimimba (2005), Stander and Hanssen (2003) and Taylor (2000)

According to the literature at least 87 species of mammals are known and/or expected to occur in the general Uis area of which 10 species (11.5%) are classified as endemic. The Namibian legislation classifies 2 species as "rare", 5 species as "vulnerable", 3 species as "specially protected game", 9 species as "protected game", 5 species as "insufficiently known", 4 species as "huntable game" and 4 species as "problem animals". Five species of bat are not listed – i.e. according to Monadjem *et al.* (2010) these bats potentially could occur in the general Uis are according to a habitat modelling programme although not yet actually confirmed.

At least 31% (27 species) of the mammalian fauna that occur or are expected to occur in the general Uis area are represented by rodents of which 5 species (18.5%) are endemic. This is followed by bats 27.6% (24 species) of which 1 species is classified as "rare". Twenty nine species (33.3%) have IUCN, CITES and SARDB international conservation status (some species have more than one conservation status). The IUCN (2021) classifies 4 species each as vulnerable (cheetah, leopard, Hartmann's mountain zebra, giraffe) and near threatened (African straw-coloured fruit bat, Commerson's roundleaf bat, striped leaf-nosed bat, brown hyena). The SARDB (2004) classifies 1 species as rare, 1 species as endangered, 2 species as vulnerable, 12 species as near threatened and 6 species as data deficient while CITES lists 2 species as Appendix 1 and 5 species as Appendix 2. The House Mouse (*Mus musculus*) is viewed as an invasive alien species to the area. *Mus musculus* are generally known as casual pests and not viewed as problematic although they are known carriers of "plague" and can cause economic losses.

Although elephant and black rhino are included in the species known/expected to occur in the Tsiseb Communal Conservancy (NACSO 2010), they are not expected to occur in/around Uis and/or the general ML134 area although may occasionally pass through and are consequently not included in Table 3.

Of the 87 species of mammals known and/or expected to occur in the general Uis area, 9 species (10.3%) are classified as endemic. Rodents (of which 5 species – 18.5% – are endemic) and bats (of which 1 species is classified as rare) are the groups least studied. Species of greatest concern in the general area are those viewed as rare in Namibia – i.e. Namibian wing-gland bat and Southern African hedgehog – and species classified as vulnerable (cheetah, leopard, Hartmann's mountain zebra, giraffe) and near threatened (African straw-coloured fruit bat, Commerson's roundleaf bat, striped leaf-nosed bat, brown hyena) by the IUCN (2021). Another important and unique species, although not observed, but known to occur in the general area, is the endemic Kaokoland slender or black mongoose (See: Cowley and Cunningham 2004, Warren *et al.* 2009).

During the fieldwork a total of 17 species (15 dry season and 12 wet season – some species observed in both seasons) were confirmed from the ML 134 area which included included 2 elephant-shrew, aardvark, rock hyrax, hare, porcupine, 6 rats and mice, 3 carnivores and 2 ungulates (Figures 19-25) – See Table 3.

A total of 100 Sherman small mammal traps (50 during the dry and wet season, respectively – See Figure 18) were set for 5 nights at 8 sites (3 nights and 5 sites during the dry season and 2 nights and 3 sites during the wet season, respectively) throughout the area (Table 4). This resulted in 34 captures (15 individuals during the dry season and 19 individuals during the wet season, respectively) of 4 species – *Elephantulus rupestris*, *Micaelamys namaquensis*, *Petromyscus collinus* and *Tatera leucogaster* – i.e. 34% capture success (30% capture success during the dry season and 38% capture success during the wet season, respectively) (Figures 19-22). Although there was a higher capture success rate during the wet season, the species captured remained the same for the seasons.

Table 4. Small mammals trap sites.

Number	Traps	Area	Habitat	Coordinates	Captures	Species	Season
1	10	ML134	Rocky ridge & Drainage line	S21°17'55.5"; E14°56'58.2"	1	*Petromyscus collinus*	Dry
					1	*Micaelamys namaquensis*	Dry
2	10	ML134	Drainage line & Gravel plain	S21°15'25.0"; E14°53'22.0"	1	*Tatera leucogaster*	Dry
					1	*Elephantulus rupestris*	Dry
3	10	ML134	Rocky ridge & Drainage line	S21°16'23.1"; E14°51'11.2"	1	*Tatera leucogaster*	Dry
					1	*Petromyscus collinus*	Dry
4	10	ML134	Rocky ridge & Gravel plain	S21°14'21.1"; E14°56'37.7"	3	*Tatera leucogaster*	Dry
					2	*Elephantulus rupestris*	Dry
5	10	ML134	Rocky ridge & Gravel plain	S21°13'52.8"; E14°56'11.2"	1	*Tatera leucogaster*	Dry
					3	*Elephantulus rupestris*	Dry
6	10	ML134	Gravel plain	S21°15'24.5"; E14°58'05.4"	6	*Tatera leucogaster*	Wet
7	15	ML134	Drainage line	S21°16'21.6"; E14°58'33.5"	5	*Tatera leucogaster*	Wet
					1	*Micaelamys namaquensis*	Wet
					1	*Elephantulus rupestris*	Wet
8	25	ML134	Gravel plain & Hill	S21°15'22.1"; E14°53'01.1"	4	*Tatera leucogaster*	Wet
					2	*Petromyscus collinus*	Wet

Figure 18. Sherman collapsible small mammal traps were baited and used to trap rodents.

Figure 19. Western rock elephant-shrew (*Elephantulus rupestris*) captures in rocky areas bordering drainage lines.

Figure 20. Namaqua rock mouse (*Micaelamys namaquensis*) associated with rocky areas.

Figure 21. The endemic pygmy rock mouse (*Petromyscus collinus*) associated with rocky terrain.

Figure 22. Bushveld gerbils (*Tatera leucogaster*) were captured in all habitats.

Figure 23. Typical dassie rat (*Petromys typicus*) middens observed in rocky terrain.

Figure 24. Yellow mongoose (*Cynictis penicillata*) burrow system are utilised by a variety of vertebrates.

Figure 25. Althouh no bats were oserved during the fieldwork, past informal mining activity has created suitable habitat for some species throughout the area.

The ML134 area is heavily impacted due to its close proximity to Uis and associated anthropogenic influences as well as current/past mining and informal mining/prospecting activities with none of the unique mammals expected to be exclusively associated with this area. The proposed mitigations – See Section 4 – are expected to minimise the overall effect on mammals potentially occurring in the area.

3.4 Avian Diversity

Bird diversity known and/or expected to occur in the Uis area, including species confirmed during the fieldwork conducted, is presented in Table 5.

Although Namibia's avifauna is comparatively sparse compared to the high rainfall equatorial areas elsewhere in Africa, approximately 658 species have already been recorded with a diverse and unique group of arid endemics (Brown *et al.* 1998, Maclean 1985). Fourteen species of birds are endemic or near endemic to Namibia with the majority of Namibian endemics occurring in the savannas (30%) of which ten species occur in a north-south belt of dry savannah in central Namibia (Brown *et al.* 1998).

Bird diversity and endemism is viewed as "average" in the general Uis area with 111-140 species, of which 6-10 species being endemic ("high" endemism) (Mendelsohn *et al.* 2000). Simmons (1998a) suggests 4-9 endemic species and an "average" ranking for southern African endemics and "low" ranking for red data birds expected from the general area. Although the Uis area is not classified as an Important Birding Area (IBA) in Namibia (Simmons 1998a) the closest such site is located 20-30km to the northwest of Uis at the Brandberg.

According to the literature at least 190 bird species [mainly terrestrial "breeding residents"] occur and/or could occur in the general Uis area at any time (Hockey *et al.* 2006, Maclean 1985, Tarboton 2001). Thirteen of the 14 Namibian endemics are expected to occur in the general area (92.9% of all Namibian endemic species or 6.8% of all the species expected to occur in the area). Seven species are classified as endangered (violet wood-hoopoe, Ludwig's bustard, white-backed vulture, tawny eagle, booted eagle, martial eagle, black stork), 2 species as vulnerable (lappet-faced vulture, secretarybird) and 5 species as near threatened (Rűppel's parrot, kori bustard, Cape eagle owl, Verreaux's eagle, peregrine falcon) (Simmons *et al.* 2015). Fifty six species have a southern African conservation rating with 8 species classified as endemic (14.3% of southern African endemics or 4.2% of all the birds expected) and 48 species classified as near endemic (85.7% of southern African endemics or 25.3% of all the birds expected) (Hockey *et al.* 2006). The IUCN (2021) classifies 1 species as critically endangered (white-backed vulture), 4 species as endangered (Ludwig's bustard, lappet-faced vulture, martial eagle, secretarybird), 1 species as vulnerable (tawny eagle) and 1 species as near threatened (kori bustard).

During the fieldwork a total of 45 species (33 dry season and 30 wet season – some species observed in both seasons) were confirmed (i.e. actually observed) from the ML 134 area (e.g. Figures 26-27) – See Table 5. The most important species confirmed from the area during the fieldwork are Ludwig's bustard (E) and Rüppell's korhaan (endemic). Three species observed during the wet season fieldwork are not included in Table 5 as these are migrant species and/or not breeding residents (common swift, Egyptian goose, yellow-billed kite).

The most important bird species from the general area are those classified as endemic to Namibia of which the Damara hornbill, bare-cheeked babbler and Herero chat are viewed as the most important due to the overall lack of knowledge of these species. Although also viewed as important, Rüppels korhaan is migratory throughout its range while the rockrunner inhabits inaccessible terrain and is widespread throughout mountainous areas in Namibia. Other species of concern are those classified as endangered (violet wood-hoopoe, Ludwig's bustard, tawny eagle, booted eagle, martial eagle, black stork) and near threatened (Rűppel's parrot, Cape eagle owl, Verreaux's eagle, peregrine falcon) (Simmons *et al.* 2015) and those species classified by the IUCN (2021) as critically endangered (white-backed vulture), endangered (Ludwig's bustard, lappet-faced vulture, martial eagle, secretarybird), vulnerable (tawny eagle) and near threatened (kori bustard). Although it is not known if vultures (e.g. white-backed vulture, lappet-faced vulture) breed in the area, such nesting sites (including all large raptor nesting sites), should these be established and/or located in future, are viewed as extremely important and should be avoided at all costs.

Table 5. Avian diversity expected (literature study) and confirmed during the fieldwork (√D = Dry season and √W = Wet season) from the general Uis (ML134) area.

Species: Scientific name	Species: Common name	Species confirmed	Namibian conservation and legal status	International status	
				Southern African status	IUCN
Struthio camelus	Common Ostrich	√W			
Scleroptila levaillantoides	Orange River Francolin			Near endemic	
Pternistis hartlaubi	Hartlaub's Spurfowl		Endemic	Near endemic	
Pternistis adspersus	Red-billed Spurfowl			Near endemic	
Coturnix coturnix	Common Quail				
Coturnix delegorguei	Harlequin Quail				
Numida meleagris	Helmeted Guineafowl				
Turnix sylvaticus	Kurrichane Buttonquail				
Indicator minor	Lesser Honeyguide				
Campethera abingoni	Golden-tailed Woodpecker				
Dendropicos fuscescens	Cardinal Woodpecker				
Dendropicos namaquus	Bearded Woodpecker				
Tricholaema leucomelas	Acacia Pied Barbet			Near endemic	
Tockus monteiri	Monteiro's Hornbill		Endemic		
Tockus damarensis	Damara Hornbill		Endemic	Near endemic	
Tockus leucomelas	Southern yellow-billed Hornbill	√D		Near endemic	
Tockus nasutus	African Grey Hornbill				
Upupa africana	African Hoopoe				
Phoeniculus purpureus	Green Wood-Hoopoe				
Phoeniculus damarensis	Violet Wood-Hoopoe		E; Endemic		
Rhinopomastus cyanomelas	Common Scimitarbill	√D			
Coracias naevius	Purple Roller	√D			
Merops hirundineus	Swallow-tailed Bee-eater	√D			
Merops apiaster	European Bee-eater				
Colius colius	White-backed Mousebird	√D		Endemic	
Urocolius indicus	Red-faced Mousebird	√D,W			
Clamator levaillantii	Levaillant's Cuckoo				
Cuculus gularis	African Cuckoo				
Chrysococcyx klaas	Klaas's Cuckoo				

Chrysococcyz caprius	Diderick Cuckoo	√[W]			
Poicephalus rueppellii	Rüppell's Parrot		NT; Endemic	Near endemic	
Agapornis roseicollis	Rosy-faced Lovebird		Endemic	Near endemic	
Tachymarptis melba	Alpine Swift				
Apus bradfieldi	Bradfield's Swift			Near endemic	
Apus affinis	Little Swift				
Apus caffer	White-rumped Swift				
Corythaixoides concolor	Grey Go-away Bird	√[D]			
Tyto alba	Barn Owl				
Otus senegalensis	African Scops Owl				
Ptilopsis granti	Southern White-faced Scops Owl				
Bubo capensis	Cape Eagle Owl		NT		
Bubo africanus	Spotted Eagle Owl				
Bubo lacteus	Verreaux's Eagle-Owl				
Glaucidium perlatum	Pearl-spotted Owlet				
Asio capensis	Marsh Owl				
Caprimulgus rufigena	Rufous-cheeked Nightjar				
Columba livia	Rock Dove				
Columba guinea	Speckled Pigeon	√[D,W]			
Streptopelia capicola	Cape Turtle Dove	√[W]			
Streptopelia senegalensis	Laughing Dove	√[D,W]			
Oena capensis	Namaqua Dove	√[D,W]			
Neotis ludwigii	Ludwig's Bustard	√[D,W]	E	Near endemic	E
Ardeotis kori	Kori Bustard		NT		NT
Lophotis ruficrista	Red-crested Korhaan			Near endemic	
Afrotis afraoides	Northern Black Korhaan	√[D,W]		Endemic	
Eupodotis rueppellii	Rüppell's Korhaan	√[D,W]	Endemic	Near endemic	
Pterocles namaqua	Namaqua Sandgrouse	√[D,W]		Near endemic	
Pterocles bicinctus	Double-banded Sandgrouse			Near endemic	
Burhinus capensis	Spotted Thick-knee				
Charadrius tricollaris	Three-banded Plover				
Vanellus armatus	Blacksmith Lapwing	√[D]			
Vanellus coronatus	Crowned Lapwing	√[D]			
Rhinoptilus africanus	Double-banded Courser				
Cursorius rufus	Burchell's Courser			Near endemic	
Cursorius temminckii	Temminck's Courser				

Elanus caeruleus	Black-shouldered Kite				
Milvus migrans	Black Kite				
Gyps africanus	White-backed Vulture		E		CE
Aegypius tracheliotos	Lappet-faced Vulture		V		E
Circaetus pectoralis	Black-chested Snake-Eagle	√[D,W]			
Circaetus cinereus	Brown Snake-Eagle				
Melierax canorus	Southern Pale Chanting Goshawk	√[D]		Near endemic	
Melierax gabar	Gabar Goshawk				
Accipiter badius	Shikra				
Accipiter minullus	Little Sparrowhawk				
Accipter ovampensis	Owambo Sparrowhawk				
Buteo vulpinus	Steppe Buzzard				
Buteo augur	Augur Buzzard				
Buteo rufofuscus	Jackal Buzzard				
Aquila nipalensis	Steppe Eagle				
Aquila rapax	Tawny Eagle		E		V
Aquila verreauxii	Verreaux's Eagle		NT		
Aquila spilogaster	African Hawk-Eagle				
Aquila pennatus	Booted Eagle		E		
Polemaetus bellicosus	Martial Eagle		E		E
Sagittarius serpentarius	Secretarybird		V		E
Polihierax semitorquatus	Pygmy Falcon				
Falco rupicolus	Rock Kestrel				
Falco rupicoloides	Greater Kestrel				
Falco chicquera	Red-necked Falcon				
Falco biarmicus	Lanner Falcon				
Falco peregrinus	Peregrine Falcon		NT		
Egretta garzetta	Little Egret				
Ardea cinerea	Grey Heron				
Ardea melanocephala	Black-headed Heron				
Ciconia nigra	Black Strork		E		
Ciconia abdimii	Abdim's Stork				
Dicrurus adsimilis	Fork-tailed Drongo				
Nilaus afer	Brubru				
Dryoscopus cubla	Black-backed Puffback				
Tchagra australis	Brown-crowned Tchagra				

Laniarius atrococcineus	Crimson-breasted Shrike			Near endemic
Telophorus zeylonus	Bokmakierie			Near endemic
Prionops plumatus	White-crested Helmet-Shrike			
Lanioturdus torquatus	White-tailed Shrike		Endemic	Near endemic
Batis pririt	Pririt Batis			Near endemic
Corvus capensis	Cape Crow			
Corvus albus	Pied Crow			
Lanius minor	Lesser Grey Shrike			
Lanius collaris	Common Fiscal	√^{D}		
Eurocephalus anguitimens	Southern White-crowned Shrike			Near endemic
Anthoscopus minutes	Cape Penduline Tit			Near endemic
Parus carpi	Carp's Tit		Endemic	Near endemic
Parus cinerascens	Ashy Tit			Endemic
Hirundo rustica	Barn Swallow			
Hirundo fuligula	Rock Martin	√^{D,W}		
Delichon urbicum	Common House Martin			
Pycnonotus nigricans	African Red-eyed Bulbul	√^{W}		Near endemic
Achaetps pycnopygius	Rockrunner		Endemic	Near endemic
Sylvietta rufescens	Long-billed Crombec			
Eremomela icteropygialis	Yellow-bellied Eremomela			
Acrocephalus baeticatus	African Reed Warbler			
Turdoides bicolor	Southern Pied Babbler			Endemic
Turdoides gymnogenys	Bare-cheecked Babbler		Endemic	
Parisoma layardi	Layard's Tit-Babbler			Endemic
Parisoma subcaeruleum	Chestnut-vented Tit-Babbler	√^{D}		Near endemic
Cisticola subruficapilla	Grey-backed Cisticola			Near endemic
Cisticola jaridulus	Desert Cisticola			
Prinia flavicans	Black-chested Prinia	√^{D}		
Camaroptera brevicaudata	Grey-backed Camaroptera			
Mirafra passerina	Monotonous Lark			
Mirafra fasciolata	Eastern Clapper Lark			Near endemic
Mirafra sabota	Sabota Lark	√^{D}		
Ammomanopsis grayi	Gray's Lark		Endemic	
Chersomanes albofasciata	Spike-heeled Lark	√^{D,W}		Near endemic
Certhilauda benguelensis	Benguela Long-billed Lark	√^{W}		Near endemic
Eremopterix leucotis	Chestnut-backed Sparrowlark			

Eremopterix verticalis	Grey-backed Sparrowlark			Near endemic
Calandrella cinerea	Red-capped Lark	√[W]		
Alauda starki	Stark's Lark			Near endemic
Monticola brevipes	Short-toed Rock Thrush			
Psophocichla litsitsirupa	Groundscraper Thrush			
Bradornis infuscatus	Chat Flycatcher			Near endemic
Melaenornis mariquensis	Marico Flycatcher	√[D,W]		Near endemic
Muscicapa striata	Spotted Flycatcher			
Cercotrichas leucophrys	White-browed Scrub-Robin			
Cercotrichas paena	Kalahari Scrub-Robin			
Namibornis herero	Herero Chat		Endemic	Near endemic
Oenanthe monticola	Mountain Wheatear	√[D,W]		Near endemic
Oenanthe pileata	Capped Wheatear			
Cercomela schlegelii	Karoo Chat			Near endemic
Cercomela tractrac	Tractrac Chat	√[D,W]		Near endemic
Cercomela familiaris	Familiar Chat	√[W]		
Myrmecocichla formicivora	Ant-eating Chat			Endemic
Onychognathus nabouroup	Pale-winged Starling	√[D]		Near endemic
Lamprotornis nitens	Cape Glossy Starling	√[D,W]		
Cinnyricinclus leucogaster	Violet-backed Starling			
Creatophora cinerea	Wattled Starling			
Chalcomitra senegalensis	Scarlet-chested Sunbird			
Nectarinia fusca	Dusky Sunbird	√[D]		Near endemic
Cinnyris mariquensis	Marico Sunbird			
Bualornis niger	Red-billed Buffalo-Weaver			
Sporopipes squamifrons	Scaly-feathered Finch			Near endemic
Plocepasser mahali	White-browed Sparrow-Weaver	√[W]		
Philetairus socius	Sociable Weaver			Endemic
Ploceus intermedius	Lesser Masked-Weaver			
Ploceus velatus	Southern Masked-Weaver	√[W]		
Ploceus rubiginosus	Chestnut Weaver			
Quelea quelea	Red-billed Quelea			
Amadina erythrocephala	Red-headed Finch			Near endemic
Estrilda erythronotos	Black-faced Waxbill			
Estrilda astrild	Common Waxbill			
Granatina granatina	Violet-eared Waxbill			

Pytilia melba	Green-winged Pytilia		
Vidua regia	Shaft-tailed Whydah		
Passer domesticus	House Sparrow		
Passer motitensis	Great Sparrow		Near endemic
Passer melanurus	Cape Sparrow	√^{D,W}	Near endemic
Passer griseus	Southern Grey-headed Sparrow		
Motacilla capensis	Cape Wagtail		
Anthus cinnamomeus	African Pipit		
Anthus vaalensis	Buffy Pipit		
Anthus similes	Long-billed Pipit		
Serinus alario	Black-headed Canary		Endemic
Crithagra atrogulariis	Black-throated Canary		
Serinus flaviventris	Yellow Canary	√^{D}	Near endemic
Serinus albogularis	White-throated Canary		Near endemic
Emberiza impetuani	Lark-like Bunting	√^{D,W}	Near endemic
Emberiza tahapisi	Cinnamon-breasted Bunting		
Emberiza capensis	Cape Bunting		Near endemic
Emberiza flaviventris	Golden-breasted Bunting		

This table excludes migratory birds (e.g. Petrel, Albatross, Skua, etc.), aquatic species (e.g. ducks, etc.) and species breeding extralimital (e.g. stints, sandpipers, etc.) and rather focuses on birds that are breeding residents or can be found in the area during any time of the year. This would imply that many more birds (e.g. Palaearctic migrants) could occur in the area depending on "favourable" environmental conditions.
Namibian status: E – Endangered, V – Vulnerable, NT – Near Threatened (Simmons *et al.* 2015)
Southern African status: Hockey *et al.* (2006)
IUCN (2021): CE – Critically Endangered, E – Endangered, V- Vulnerable, NT – Near Threatened. All other species not listed are viewed as "Least Concern" by IUCN (2021)

Source for literature review: Brown *et al.* (1998), Hockey *et al.* (2006), IUCN (2021), Komen (n.d.), Little and Crowe (2011), Maclean (1985), Peacock (2015), Simmons *et al.* (2015), Tarboton (2001)

Figure 26. The endemic Rüppel's korhaan (*Eupodotis rueppellii*) observed in the area.

Figure 27. Ludwig's bustard (*Neotis ludwigii*) are classified as endangered by the IUCN (2021) and from Namibia (Simmons *et al.* 2015), are viewed as the most important birds confirmed from the area, although they are migratory and move long distances throughout their range. However, they are secretive breeders and nest on sparsely vegetated gravel plains.

The ML134 area is heavily impacted due to its close proximity to Uis and associated anthropogenic influences as well as current/past mining and informal mining/prospecting activities with none of the unique birds expected to be exclusively associated with this area. The proposed mitigations – See Section 4 – are expected to minimise the overall effect on birds potentially occurring in the area.

3.5 Tree and Shrub Diversity

It is estimated that at least 104 species of larger trees and shrubs (>1m in height) occur in the general Uis area (Mannheimer and Curtis 2018).

The trees and shrubs known, and/or expected to occur in the general area (derived from Mannheimer and Curtis 2018) is presented in Table 6 below. Species indicated are know from the quarter-degree square distribution principle used and don't necessarily occur throughout the entire area.

Twelve species of trees and shrubs (11.5%) expected to occur in the general Uis area are classified as endemic, 7 species as near endemic (6.7%), 25 species (24%) are protected by the Forest Act No. 12. of 2001, 4 species (3.9%) are protected under the Nature Conservation Ordinance No. 4 of 1975 while 6 species (5.8%) are classified as CITES Appendix 2 species. All the trees with some kind of conservation and/or protected status are viewed as important in the general Uis area. The most important species are viewed as *Acacia montis-usti*, *Adenia pechuelii*, *Aloe dichotoma*, *Caesalpinia pearsonii*, *Commiphora dinteri*, *Commiphora kaokoensis*, *Commiphora kraeuseliana*, *Commiphora saxicola*, *Commiphora virgata*, *Commiphora wildii*, *Cyphostemma currorii*, *Erythrina decora, Manuleopsis dinteri*, *Moringa ovalifolia*, *Sesamothamnus guerichii*, *Sterculia africana*, *Sterculia quinqueloba* and *Welwitschia mirabilis* (See Table 6). The IUCN (2021) classifies *Acacia montis-usti* as near threatened and 15 other species as least concern although not all the flora has been assessed by the IUCN Red Data Book. However, not all these species are expected to actually occur in the Uis (ML134) area, but rather the larger general area (e.g. *Acacia montis-usti* – Brandberg; *Welwitschia mirabilis* – west/north of Brandberg, etc.).

Although at least 104 larger species of trees and shrubs are known and/or expected to occur in the general area only 14 (17 spp. including small shrubs), 16 and 26 species were identified in the following habitats – hills/ridges, gravel plains and drainage lines (rivers) – throughout the ML134 area, respectively.

Although not included in Table 6, 8 smaller shrub species – i.e. *Calicorema capitata*, *Euphorbia lignosa*, *Leucosphaera bainesii*, *Pelargonium* spp., *Petalidium variable*, *Sarcostemma viminale*, *Sarcocaulon* spp. and *Zygophyllum* spp. – were observed in the hills/ridges; 6 smaller shrub species – i.e. *Calicorema capitata*, *Hoodia currorii*, *Leucosphaera bainesii*, *Monechma cleomoides*, *Petalidium variable* and *Sarcocaulon* spp. – were observed in the undulating gravel plain areas and 2 smaller shrub species – i.e. *Calicorema capitata* and *Cryptolepis decidua* – were observed in the drainage line areas. A total of 42 species of larger trees and shrubs were identified throughout the area (See Table 6 excluding the smaller shrub species mentioned above). All species, including the smaller shrub species, would result in a total of at least 52 species confirmed from the general area.

The most important protected species (including endemic/near endemic, etc.) are viewed as:

Hills/Ridges

- *Commiphorra dinteri*, *Commiphora glaucescens*, *Commiphora saxicola*, *Commiphora virgata*, *Commiphora wildii*, *Maerua schinzii*, *Moringa ovalifolia* and *Sterculia africana*

Undulating gravel plains

- *Acacia erioloba*, *Commiphora saxicola*, *Commiphora virgata*, *Commiphora wildii*, *Hoodia currorii*, *Moringa ovalifolia* and *Sterculia africana*

Drainage lines

- *Acacia erioloba*, *Boscia albitrunca*, *Euclea pseudebenus*, *Faidherbia albida* and *Maerua schinzii*

The protected and/or unique species identified throughout the ML134 area occur widespread throughout Namibia and not limited to the Uis and/or ML134 area. However, unique habitats such as ephemeral drainage lines have larger specimens which often serve as habitat for a variety of species – e.g. raptor breeding sites, bark and cavity dwelling species (bats, birds and reptiles), etc. – and stabilise river banks while hills have a higher diversity of species

Table 6. Tree and shrub diversity expected (literature study) and confirmed during the fieldwork (Dry and Wet seasons combined) from the general Uis (ML134) area. The trees and shrubs known, and/or expected to occur in the general area are derived from Mannheimer and Curtis (2018).

Species Expected: Scientific name	Species confirmed			Namibian conservation and legal status	International status (IUCN 2021)
	Hills/Ridges	Undulating gravel plains	Drainage lines		
Acacia erioloba		√	√	Protected (F#)	LC
Acacia erubescens			√		
Acacia hebeclada					
Acacia hereroensis					
Acacia karroo					
Acacia mellifera			√		
Acacia montis-usti				End	NT
Acacia reficiens	√	√	√		
Acacia senegal					
Acacia tortilis			√		
Adenia pechuelii				Protected (F#), End	LC
Adenolobus garipensis			√		
Adenolobus pechuelii	√				
Albizia anthelmintica				Protected (F#)	
Aloe dichotoma				Protected (F#), NC, C2, N-end	
Aloe litoralis				NC, C2	
Azima tetracantha			√		
Boscia albitrunca			√	Protected (F#)	LC
Boscia foetida	√	√	√		
Cadaba aphylla					
Cadaba schroeppelii				N-end	
Caesalpinia pearsonii				End	
Caesalpinia rubra	√		√		
Catophractes alexandri		√			
Combretum imberbe				Protected (F#)	LC
Commiphora dinteri		√		Protected (F#), End	
Commiphora glandulosa		√			LC
Commiphora glaucescens	√			N-end	LC
Commiphora kaokoensis				End	LC
Commiphora kraeuseliana				Protected (F#), End	

Commiphora pyracanthoides		√			
Commiphora saxicola	√	√		Protected (F#), End	
Commiphora tenuipetiolata	√	√			
Commiphora virgata	√	√		Protected (F#), End	
Commiphora wildii	√	√		Protected (F#), N-end	
Cordia sinensis			√		
Croton gratissimus					
Cyphostemma currorii				Protected (F#), NC	
Dichrostachys cinerea					
Diospyros acocksii					
Diospyros lycioides					
Dombeya rotundifolia					
Ehretia alba					
Erythrina decora				Protected (F#), End	
Elephantorrhiza suffruticosa		√			
Euclea pseudebenus			√	Protected (F#)	LC
Euclea undulata					
Euphorbia damarana	√			End, C2	
Euphorbia guerichiana				C2	LC
Euphorbia virosa	√			C2	
Faidherbia albida			√	Protected (F#)	LC
Ficus cordata				Protected (F#)	LC
Ficus ilicina					
Ficus sycomorus				Protected (F#)	LC
Gossypium anomalum			√		
Gossypium triphyllum					
Grewia bicolor			√		
Grewia flava					
Grewia flavescens					
Grewia tenax			√		
Grewia villosa			√		
Gymnosporia senegalensis			√		
Ipomoea adeniodes					
Laggera decurrens					
Lycium bosciifolium			√		
Lycium eenii					
Maerua juncea			√		
Maerua parvifolia					
Maerua schinzii	√	√	√	Protected (F#)	LC

Melianthus comosus					
Manuleopsis dinteri				End	
Montinia caryophyllacea					
Moringa ovalifolia	√	√		Protected (F#), NC, N-end	
Mundulea sericea			√		
Olea europaea					
Osyris lanceoloata					
Ozoroa crassinervia					
Parkinsonia africana		√			
Pechuel-Loeschea leubnitziae			√		
Phaeoptilum spinosum			√		
Rotheca myricoides					
Rhigozum brevispinosum					
Salsola spp.					
Salvadora persica			√		
Searsia burchellii				Protected (F#)	
Searsia ciliata					
Searsia marlothii					
Searsia pyroides					
Sesamothamnus guerichii				N-end	
Steganotaenia araliacea					
Sterculia africana	√	√		Protected (F#)	LC
Sterculia quinqueloba				Protected (F#)	
Tamarix usneoides				Protected (F#)	
Terminalia prunioides			√		
Tetradenia riparia					
Tinnea rhodesiana					
Terminalia pruniodes					
Vangueria cyanescens					
Vangueria infausta					
Vernonia cinerascens					
Welwitschia mirabilis				Protected (F#); N-end; C2	
Ximenia americana					
Ziziphus mucronata				Protected (F#)	LC
Zygophyllum stapffii				End	

Endemic and Near-endemic – (Mannheimer and Curtis 2018)
F# – Forest Act No. 12 of 2001
NC – Nature Conservation Ordinance No. 4 of 1975

NT – Near Threatened; LC – Least Concern (IUCN 2021)
C2 – CITES Appendix 2 species

Source for literature review: Burke (2005), IUCN (2021), Loots (2005), Mannheimer and Curtis (2018), Rothmann (2004), Steyn (2003) including unique species – e.g. *Commiphora* spp., etc. However, many species (e.g. *Commiphora* spp., *Euphorbia* spp., etc.) are relatively easily to transplant/relocate and could be relocated to other similar habitat should mining/prospecting activities be necessary in the areas they occur in.

Hills/Ridges

Seventeen species of larger trees and shrubs were encountered along various transects totalling 2,000m in various hills/ridge habitats during the dry and wet seasons, respectively (12 spp. each season and 1,000m each season). *Petalidium variable* (41%), *Commiphora virgata* (19%) and *Calicorema capitata* (9%) and *Commiphora virgata* (29%), *Leusophaera bainessi* (21%) and *Commiphora saxicola* (15%) were the most dominant species observed during the fieldwork in this habitat during the dry and wet seasons, respectively (Figure 28). *Commiphora* species account for 29% and 48% of the tree/shrub species composition in these habitats during the dry and wet seasons, respectively. Protected species – *Commiphora dinteri* (1.5%), *Commiphora saxicola* (7.5%), *Commiphora virgata* (24%), *Commiphora wildii* (4%), *Euphorbia virosa* (4%) and *Maerua schinzii* (0.5%) (Figures 29-33) – account for 41.5% (both seasons) of the trees/shrubs in this habitat. The protected species are widespread throughout Namibia and not exclusively associated with the Uis/ML134 area. However, as the hill habitats are very diverse, all unnecessary activities should be avoided in this habitat as far as possible and/or remove and relocate suitable species. Permits would also be required to remove these plant species.

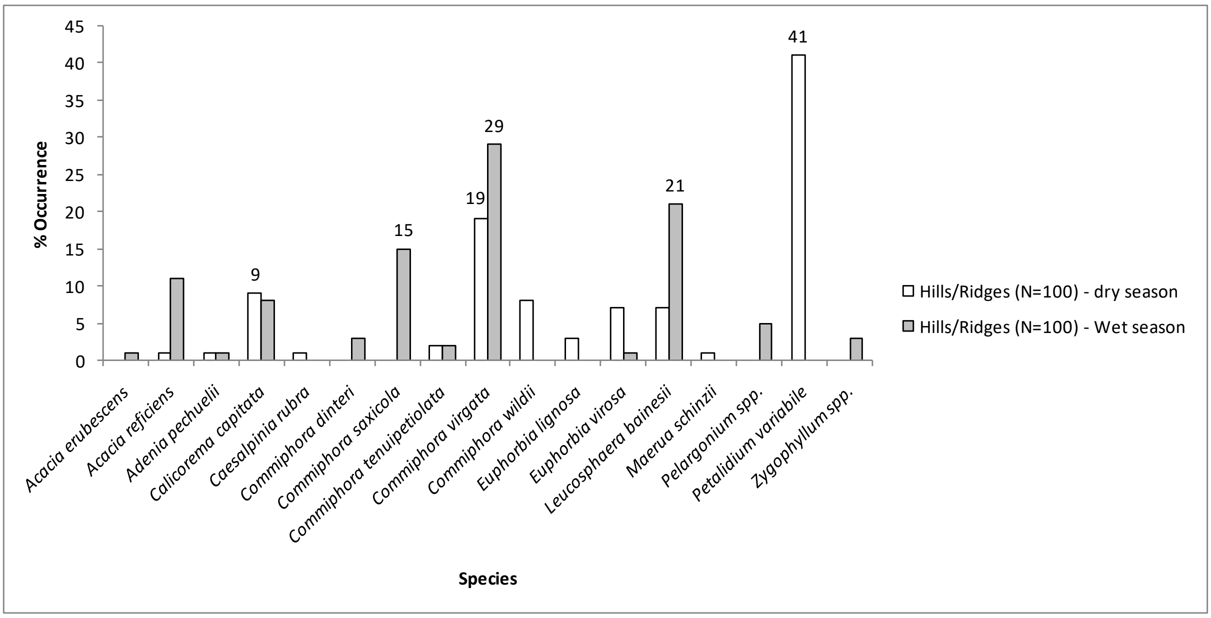

Figure 28. Tree and shrub species composition along various transects (total length – 1,000m @ 10m intervals) in the hills/ridges habitat (N=100 points).

Figure 29. *Commiphora saxicola* (rock corkwood) – protected F; endemic – with typical folded and deeply toothed leaves, are common in rocky habitat.

Figure 30. *Commiphora virgata* (slender corkwood) – protected F; endemic – are the most commonly encountered corkwood species on hills/ridges.

Figure 31. *Commiphora wildii* (oak-leaved corkwood) – protected F; near endemic – observed in rocky terrain.

Figure 32. *Euphorbia virosa* (candelabra euphorbia) – CITES Appendix 2 species – on hills/ridges – i.e. in rocky terrain.

Figure 33. *Maerua schinzii* (ringwood tree) – protected F – observed on hillside although typically seen on gravel plains.

Undulating gravel plains

Eighteen species of larger trees and shrubs were encountered along various transects totalling 1,800m in various undulating gravel plain habitats during the dry and wet seasons, respectively (10 and 13 spp. during the dry and wet seasons each and 1,000m and 800m each season). *Calicorema capitata* (38%), *Petalidium variable* (16%), *Monechma gentisifolia* (14%) and *Commiphora virgata* (26.3%), *Leucosphaera bainesii* (22.5%) and *Commiphora dinteri* (12.5%) were the most dominant species observed during the fieldwork in this habitat during the dry and wet seasons, respectively (Figure 34). *Commiphora* species account for 27.5% of the tree/shrub species composition in these habitats while protected species – *Commiphora dinteri* (6.3%), *Commiphora saxicola* (0.6%), *Commiphora virgata* (17.7%), *Commiphora wildii* (2.5%), *Euphorbia virosa* (2.5%), *Maerua schinzii* (0.6%), *Moringa ovalifolia* (0.6%) and *Sarcocaulon* spp. (1%) (Figures 35-39) – account for 31.2%. The protected species are widespread throughout Namibia and not exclusively associated with the Uis/ML134 area. Suitable species should be removed and relocated. Permits would also be required to remove these plant species.

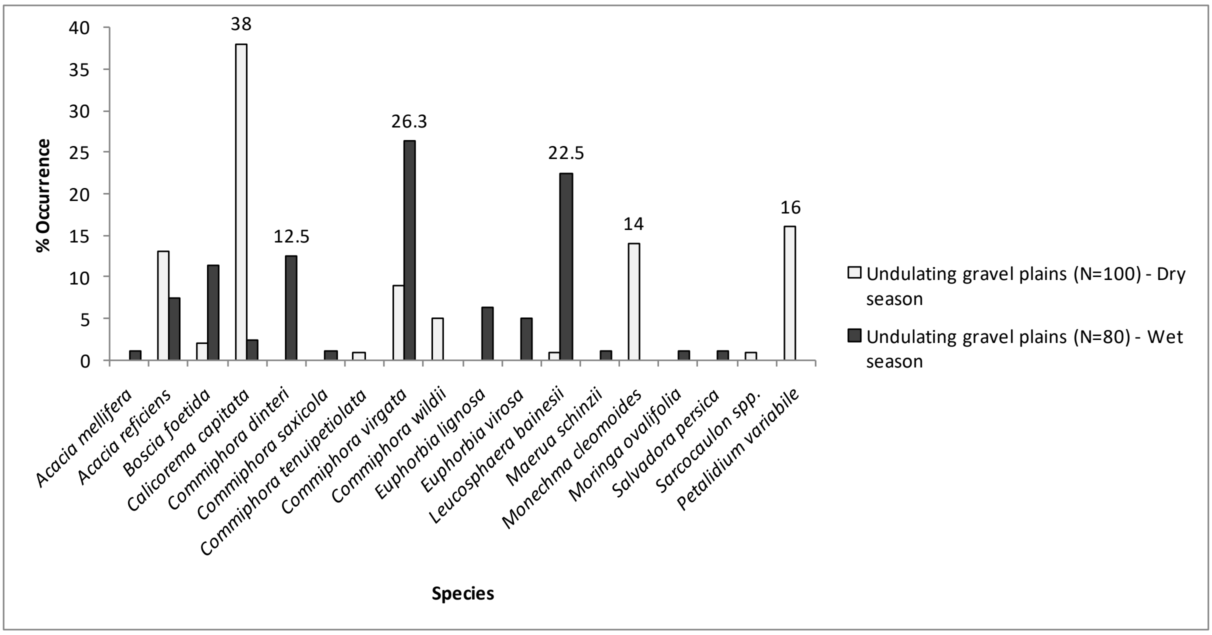

Figure 34. Tree and shrub species composition along various transects (total length – 1,000m @ 10m intervals) in the undulating gravel plains habitat (N=100 points).

Figure 35. *Commiphora virgata* (slender corkwood) – protected F; endemic – was the most common protected tree species encountered on the undulating gravel plain habitats.

Figure 36. *Hoodia currorii* (Namib Hoodia) – protected NC – observed in flower after the recent rains in late January 2022.

Figure 37. A few *Sarcocaulon* spp. (probably *S. flavescens*) – near endemic – were observed in area.

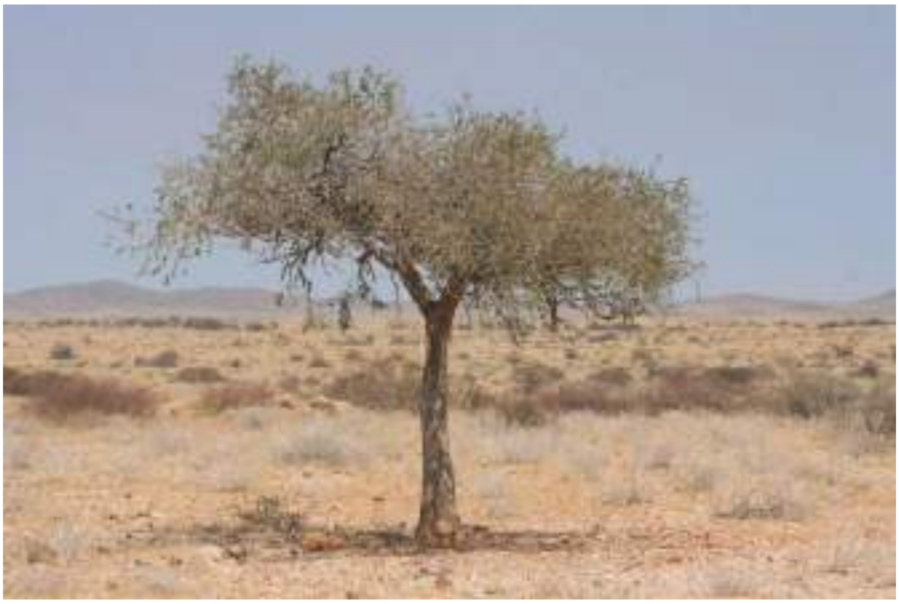

Figure 38. Only a few scattered *Boscia albitrunca* (shepherd's tree) – protected F – individuals were observed throughout the area.

Figure 39. Although not included in the various transects conducted in this habitat, *Moringa ovalifolia* (phantom tree) – protected F, NC, N-end – and *Maerua schinzii* (ringwood tree) – protected F – individuals were also encountered.

Drainage lines

Thirteen species of larger trees and shrubs were encountered along various transects totalling 1,700m in various drainage line habitats during the dry and wet seasons, respectively (13 spp. during the dry and wet seasons each and 1,000m and 700m each season). *Acacia erioloba* (25%), *Acacia reficiens* (17%), *Euclea pseudebenus* (15%) and *Acacia reficiens* (33%), *Boscia foetida* (15.7%), *Commiphora pyracanthoides* (10%) and *Cordia sinensis* (10%) were the most dominant species observed during the fieldwork in this habitat during the dry and wet seasons, respectively (Figure 40). *Acacia* species account for 39% of the tree/shrub species composition in these habitats while protected species – *Acacia erioloba* (12.5%), *Boscia albitrunca* (2%), *Euclea pseudebenus* (7.5%) and *Maerua schinzii* (0.7%) (Figures 41-43) – account for 22.7%. However, the protected species are widespread throughout Namibia and not exclusively associated with the Uis/ML134 area. On the other hand, these trees along drainage lines are usually large specimens which serve as unique habitat to a variety of vertebrate fauna (e.g. cavity dwellers, perching/roosting/nesting sites, etc.) (Figure 44). Cognisance of the importance of these habitats is imperative and developments should be limited in drainage lines in such an arid environment. Permits would also be required to remove these species.

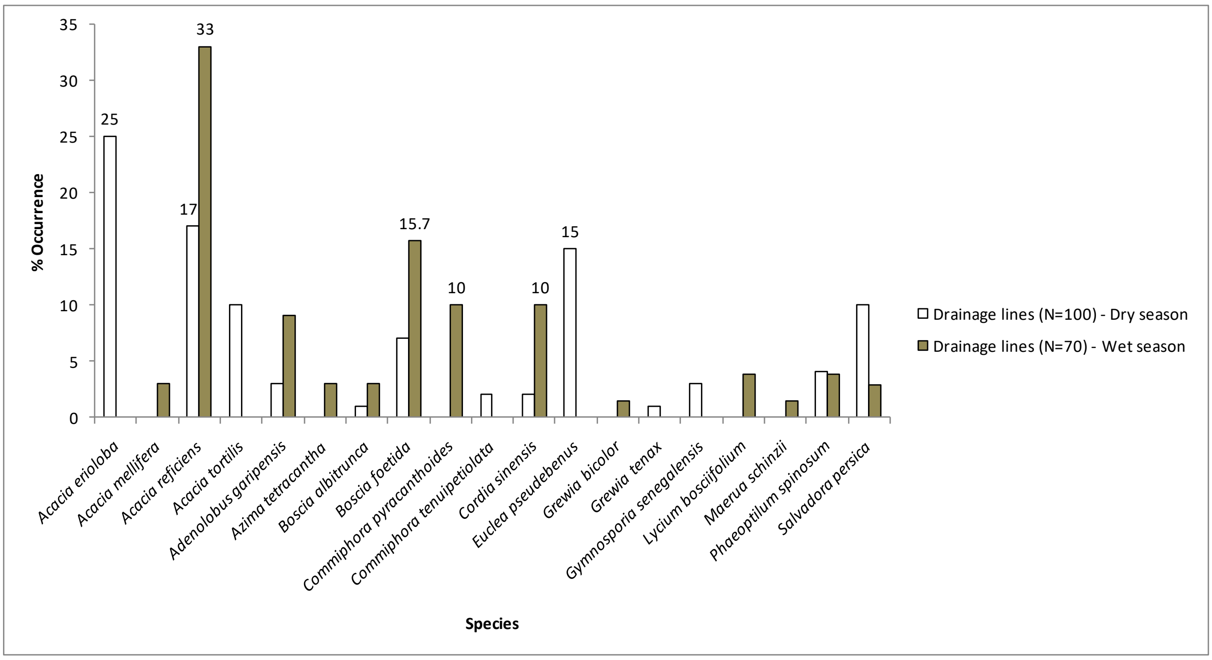

Figure 40. Tree and shrub species composition along various transects (total length – 1,000m @ 10m intervals) in the river habitat (N=100 points).

Figure 41. The larger drainage lines are well vegetated and include a variety of species.

Figure 42. The smaller drainage lines are well vegetated, although with fewer protected tree species.

Figure 43. *Acacia erioloba* (camel thorn) – protected F – and *Euclea pseudebenus* (wild ebony) – protected F – are some of the largest tree specimens in the various larger drainage lines.

Figure 44. Rough bark is usually associated with old growth tree specimens encountered in drainage lines which serve as habitat to a variety of vertebrate species (e.g. bats, reptiles, etc.).

The ML134 area is heavily impacted due to its close proximity to Uis and associated anthropogenic influences as well as current/past mining and informal mining/prospecting activities with none of the unique larger tree/shrub species expected to be exclusively associated with this area. The proposed mitigations – See Section 4 – are expected to minimise the overall effect on trees/shrubs potentially occurring in the area.

3.6 Grass Diversity

It is estimated that at least 6-72 grasses (Müller 2007 [72spp.], Burke 2005 [6spp.], Van Oudshoorn 2012 [52spp.]) – approximate total of 80 species – occur in the general Uis area. The grasses known and/or expected to occur in the general area ([1]Müller 2007, [2]Van Oudtshoorn 2012 and [3]Burke 2005) is presented in Table 7 below. Of the approximately 80 grasses that are expected in the general area, 2 species is viewed as endemic (*Eragrostis omahekensis*, *Stipagrostis damarensis*), with *S. damarensis* only occurring in the central and northern Namib in dry river courses (Burke 2005, Müller 2007) (Table 7).

Although between 6 and 72 grasses are known and/or expected to occur in the general area only 5, 5 and 9 species and 4, 3 and 3 species were identified in the following habitats during the dry and wet season – hills/ridges, gravel plains and drainage lines (rivers) – throughout the ML134 area, respectively – See Table 7. *Stipagrostis ciliata* was observed on undulating gravel plains during wet season observation although not included in Table 7.

Hills/Ridges
Four species of grass were encountered along various transects totalling 340m in this habitat in the ML134 area. *Stipagrostis uniplumis* (31.2%) and *Aristida adscensionis* (29.4%) were the most dominant grass species observed during the fieldwork (Figure 45).

Undulating gravel plains
Six species of grass were encountered along various transects totalling 335m in this habitat in the ML134 area. Bare ground (43.8%) and *Stipagrostis uniplumis* (30.5%) were the most dominant grass species observed during the fieldwork (Figure 33). The high percentage of bare ground – 43.8% – indicates the overall dry condition and aftermath of the drought experienced in the general area (Figure 45).

Drainage lines

Five species of grass were encountered along various transects totalling 190m in this habitat in the ML134 area. *Stipagrostis hochstetteriana* (34.2%) and *Stipagrostis uniplumis* (32.1%) were the most dominant grass species observed during the fieldwork (Figure 45).

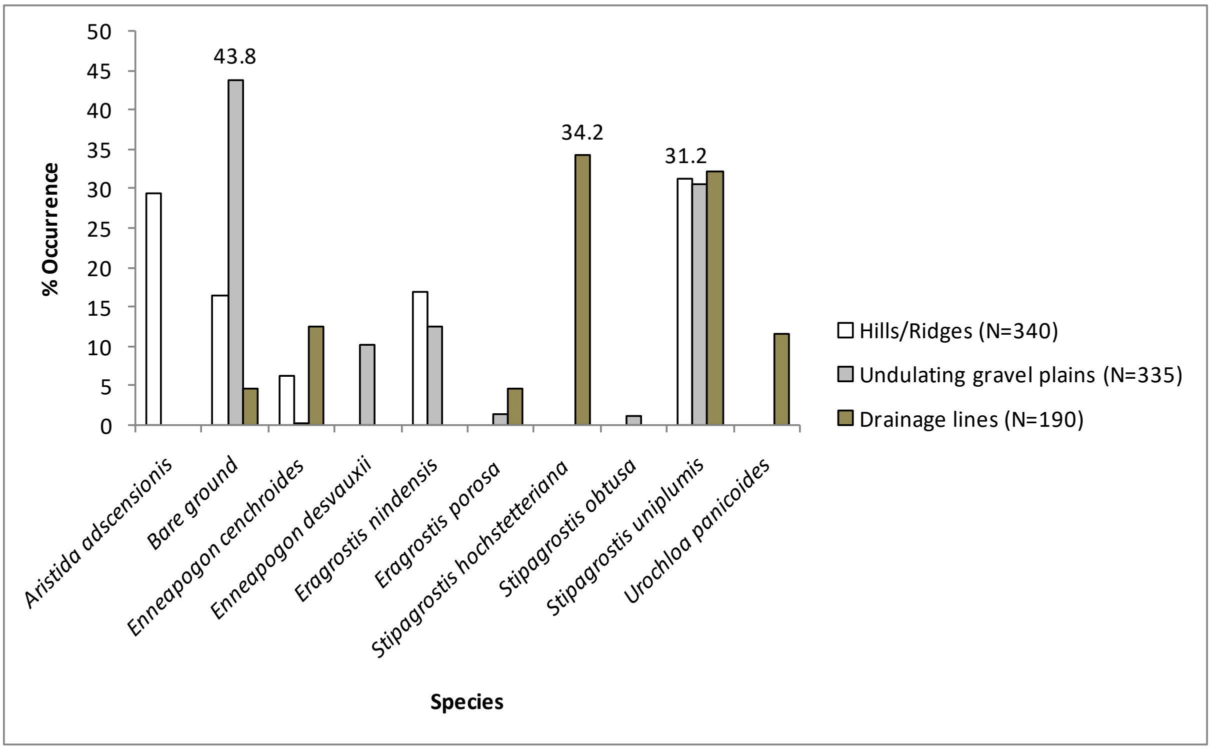

Figure 45. Grass species composition along various transects in various habitats (340m, 335m and 190m – i.e. data points @ 1m intervals) during the dry season.

Figure 46. The lack of grass cover is evident in the undulating gravel plain habitat.

During the wet season grass species and herb species were combined at each habitat indicating the relationship between rainfall and herb growth not observed during the dry season fieldwork (Figure 47). Herbs accounted for 60%, 27.7% and 16.8% of the flora along the various transects during the wet season in the hills/ridges, undulating gravel plains and drainage line habitats, respectively (Figure 49).

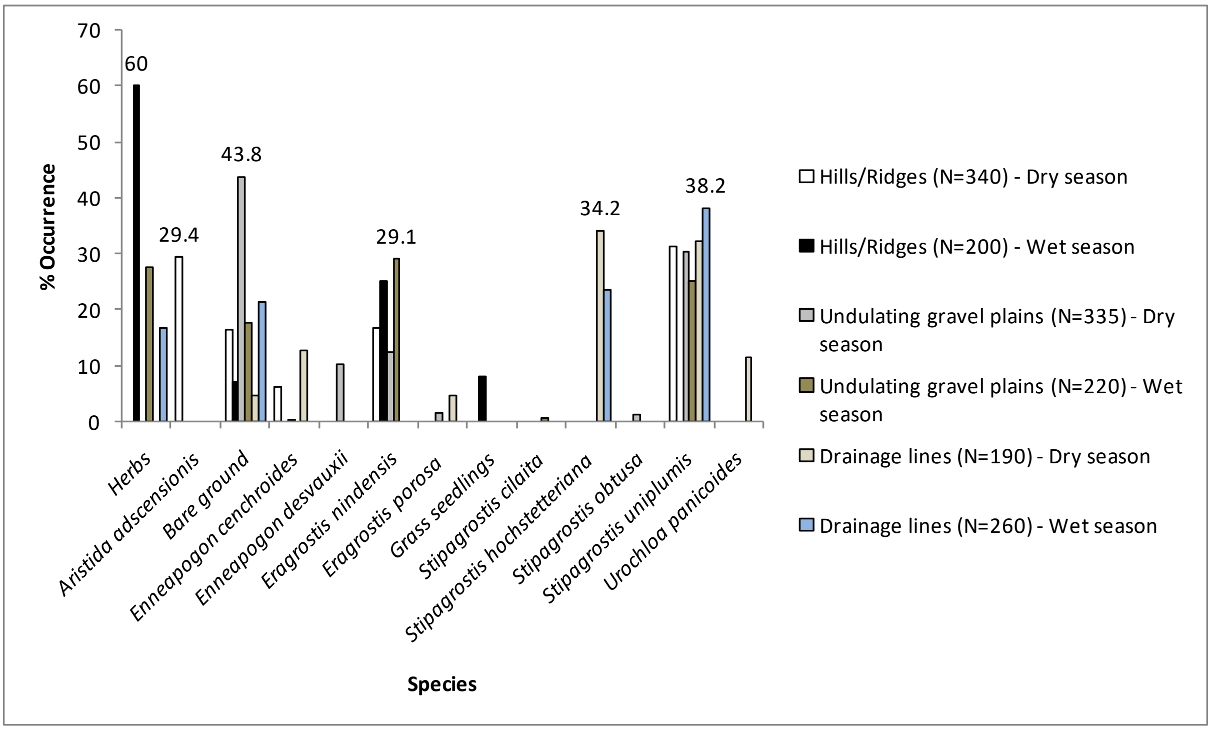

Figure 47. Grass and herb species composition along various transects in various habitats (340m, 335m and 190m – i.e. data points @ 1m intervals) during the dry season and (200m, 220m and 260m – i.e. data points @ 1m intervals) during the wet season fieldwork.

Figure 48. A combination of herbs and grasses as observed during the wet season while very few herbs were observed during the dry season (See Figure 46).

Table 7. Grass diversity expected (literature study) and confirmed during the fieldwork ($\surd^{D}$ = Dry season and $\surd^{W}$ = Wet season) from the general Uis (ML134) area. The grasses known, and/or expected to occur in the general area are derived [1]Müller (2007), [2]Van Oudtshoorn (1999), [3]Burke (2005).

Species: Scientific name	Species confirmed			Ecological Status *	Grazing Value *
	Hills/Ridges	Undulating gravel plains	Drainage lines		
[1,2]*Andropogon chinensis*				Increaser 1	Average
[2]*Andropogon eucomus*				Increaser 2	Low
[1]*Anthephora argentea*				Decreaser	High
[1,2]*Anthephora pubescens*				Decreaser	High
[1]*Anthephora schinzii*				Increaser 2	Low
[1,2]*Aristida adscensionis*	$\surd^{D}$			Increaser 2	Low
[1,2]*Aristida congesta*				Increaser 2	Low
[1]*Aristida effusa*				Increaser 2	Low
[1,2]*Aristida meridionalis*				Increaser 2	Low
[1]*Aristida rhiniochloa*				Increaser 2	Low
[1,2]*Bachiaria deflexa*				Increaser 2	Average
[1]*Brachiaria malacodes*				?	Low
[1]*Brachiaria glomerata*				Decreaser	Average
[1,2]*Brachiaria nigropedata*				Decreaser	High
[1,2]*Cenchrus ciliaris*				Decreaser	High
[1,2]*Centropodia glauca*				Decreaser	High
[1,2]*Chloris virgata*				Increaser 2	Average
[2]*Cladoraphis spinosa*				Increaser 1	Low
[1,2]*Cynodon dactylon*				Increaser 2	High
[1,2]*Dactyloctenium aegyptium*				Increaser 2	Low
[1]*Danthoniopsis ramosa*				?	High
[1,2]*Dichanthium annulatum*				Decreaser	High
[2]*Diplachne fusca*				Decreaser	High
[1]*Echinochloa colona*				?	Low
[2]*Elionurus muticus*				Increaser 2	Low
[1,2]*Enneapogon cenchroides*	$\surd^{D}$		$\surd^{D}$	Increaser 2	Low
[1,2]*Enneapogon desvauxii*		$\surd^{D}$		Intermediate	Average
[1,2]*Enneapogon scaber*				?	Low
[1,2,3]*Enneapogon scoparius*				Increaser 2	Low
[1]*Entoplocamia aristulata*				Intermediate	Low

[1,2]*Eragrostis annulata*				Increaser 2	Low
[1]*Eragrostis cylindriflora*			√^{D}	?	Low
[2]*Eragrostis biflora*				Increaser 2	Low
[2]*Eragrostis cilianensis*				Increaser 2	Low
[1,2]*Eragrostis echinochloidea*				Increaser 2	Average
[1]*Eragrostis homomalla*				?	Low
[2]*Eragrostis lehmanniana*				Increaser 2	Average
[1,2]*Eragrostis nindensis*	√^{D,W}	√^{D,W}		Increaser 2	Average
[1]*Eragrostis omahekensis* [E]				?	Low
[1]*Eragrostis porosa*		√^{D}	√^{D}	Intermediate	Low
[1]*Eragrostis rigidior*				Increaser 2	Average
[1,2]*Eragrostis rotifer*				Intermediate	Low
[1]*Eragrostis scopelophila*				?	High
[1,2]*Eragrostis superba*				Increaser 2	Average
[1,2]*Eragrostis trichophora*				Increaser 2	Average
[1,2]*Eragrostis viscosa*				Increaser 2	Low
[1,2,3]*Fingerhuthia africana*				Decreaser	Average
[1,2]*Heteropogon contortus*				Increaser 2	Average
[1,2]*Hyparrhenia hirta*				Increaser 1	Average
[1]*Leptochloa fusca*				?	Average
[1,2]*Microchloa caffra*				Increaser 2	Low
[1]*Monelytrum luederitzianum*				?	Average
[1,2]*Melinis repens*				Increaser 2	Low
[1]*Odyssea paucinervis*				?	Average
[1,2]*Oropetium capense*				?	Low
[1,2]*Panicum coloratum*				Decreaser	High
[1,2]*Panicum maximum*				Decreaser	High
[2]*Panicum repens*				Decreaser	High
[1]*Pogonarthria fleckii*				Increaser 2	Low
[2]*Polypogon monspeliensis*				?	Average
[1,2,3]*Schmidtia kalahariensis*			√^{D}	Increaser 2	Low
[1,2]*Schmidtia pappophoroides*				Decreaser	High
[1]*Setaria appendiculata*				?	Average
[1,2]*Setaria verticillata*			√^{D,W}	Increaser 2	Average
[1]*Sorghum bicolour*				?	Average
[1,2]*Sporobolus festivus*				Increaser 2	Low
[1,2]*Stipagrostis ciliata*				Decreaser	High
[3]*Stipagrostis damarensis* [E]					

[1]*Stipagrostis giessii*				?	Average
[1,2]*Stipagrostis hirtigluma*				Increaser 2	Low
[1,3]*Stipagrostis hochstetteriana*			$\surd^{D,W}$	Decreaser	Average
[1,2]*Stipagrostis namaquensis*			$\surd^{D}$	?	Average
[1,2]*Stipagrostis obtusa*	$\surd^{W}$	$\surd^{D,W}$		Decreaser	High
[1,2,3]*Stipagrostis uniplumis*	$\surd^{D,W}$	$\surd^{D,W}$	$\surd^{D,W}$	Increaser 2	Average
[1,2]*Tricholaena monachne*				Increaser 2	Average
[1]*Triraphis purpurea*				?	Low
[1]*Triraphis ramosissima*	$\surd^{D}$			?	Average
[1,2]*Tragus berteronianus*				Increaser 2	Low
[1]*Tragus racemosus*				Increaser 2	Low
[1]*Urochloa brachyura*				?	Average
[1]*Urochloa panicoides*			$\surd^{D}$	?	Low

Endemic – (Burke 2005, Müller 2007)
? – not classified in literature, but often similar to other species within the genus

Source for literature review: Burke (2005), Müller (2007), Van Oudtshoorn (2012)

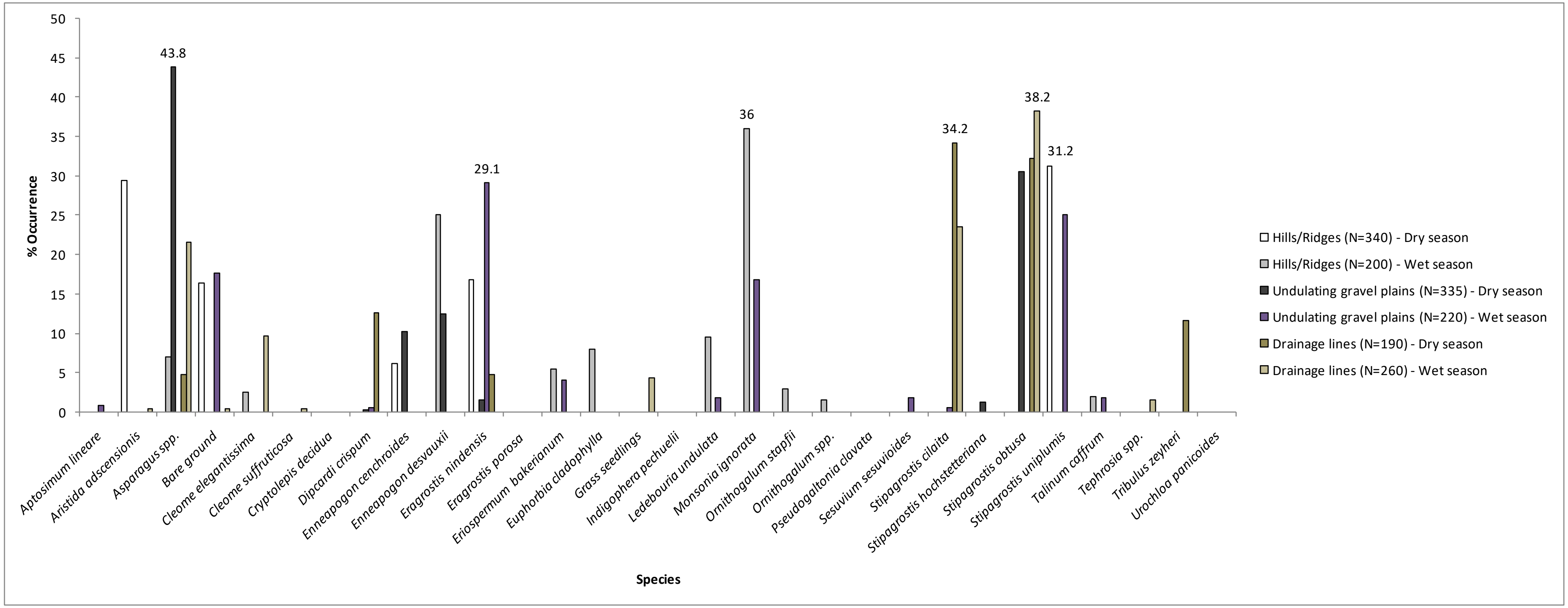

Figure 49. Grass and herb species composition along various transects in various habitats (340m, 335m and 190m – i.e. data points @ 1m intervals) during the dry season and (200m, 220m and 260m – i.e. data points @ 1m intervals) during the wet season fieldwork. Grass seedings are species that could not be acruately indentified due to the stage of germination, but mostly viewed as *Stipagrostis* species.

There was an increase in the presence of herbs after the first rains, especially on the hills/ridges throughout the area, while *Stipagrostis* species dominated the grass species composition typical of the dry parts of Namibia (See Figures 47, 49).

The ML134 area is heavily impacted due to its close proximity to Uis and associated anthropogenic influences as well as current/past mining, informal mining/prospecting activities and drought conditions with none of the unique grass species expected to be exclusively associated with this area. The proposed mitigations – See Section 4 – are expected to minimise the overall effect on grasses potentially occurring in the area.

3.7 Other Species

Other species observed throughout the proposed development area included the following herbs, etc. (Table 8). This list is not comprehensive – i.e. many more species are known and/or expected to occur in the area – as this survey was conducted during the dry season after/during a period of drought and during the onset of the wet season after the first rains.

Table 8. Other species – bulbs, herbs, etc. – confirmed in various habitats during the fieldwork ($\surd^{D}$ = Dry season and $\surd^{W}$ = Wet season) throughout the Uis/ML134 area.

	Habitat			Status
Species	**Hills/Ridges**	**Undulating gravel plains**	**Drainage lines**	
Acanthopsis disperma		√W		
Albuca fleckii	√W	√W		
Aptosimum lineare		√W		
Aptosimum lugardiae			√D	
Aptosimum spinescens		√W		
Asparagus spp.			√W	
Avonia albissima		√W		N-end; NC
Barleria lanceolata	√D			End
Blepharis gigantea	√D		√W	
Cleome eleantissima		√W	√W	
Cleome foliosa		√W		
Cleome suffruticosa	√W	√W	√D,W	
Corallocarpus welwitschii			√W	
Crinum macowanii		√W		
Cryptolepis decidua	√D		√W	
Cucumis africanus			√D	
Dactyliandra welwitschii			√D,W	N-end
Dipcardi crispum	√W	√W		
Dipcardi glaucum	√W	√W		
Eriospermum bakerianum	√W	√W		
Eriospermum roseum	√W			N-end
Euphorbia glanduligera		√D	√D,W	
Euphorbia lignosa	√D	√D		
Euphorbia phylloclada	√D,W	√W	√D	
Forsskaolea candida			√D	
Geigeria pectidia		√D,W	√D,W	
Heliotropium ciliatum		√W		
Hibiscus elliottiae			√W	

Hoodia currorii		√D,W		NC
Indogophera alternans	√W	√W	√W	
Indogophera auricoma			√W	
Indogophera pechuelii		√W	√W	
Indogophera spp.			√D	
Jamesbrittenia spp.			√W	
Kissenia capensis		√W	√D,W	
Kohautia caespitosa			√W	
Lachenalia spp.	√W			
Ledebouria undulata	√W	√W		
Leucasphaera bainesii	√D,W	√D,W		
Limeum argute-carinatum		√W		
Lophiocarpus polystachyus			√W	
Monechma cleomoides	√D,W	√D,W	√D,W	
Monechma gentisifolium	√W	√W		
Monsonia ignorata	√W	√W		
Oncocalyx welwitschii		√W	√W	N-end
Otoptera burchellii			√W	
Pelargonium spp.	√W			
Pergularia daemia			√D,W	
Petalidium variabile	√D,W	√D,W	√D,W	
Pseudogaltonia clavata	√W			
Sarcocaulon spp.	√D,W	√D,W		NC
Senna italica		√W		
Sesamum triphyllum			√D,W	
Sesbania sesban			√W	
Sesuvium sesuvioides		√W		
Solanum burchelllii			√W	
Talinum caffrum		√W	√W	
Tapinanthus oleifolius		√W	√D,W	
Tribulus terrestris	√W	√W	√D,W	
Tribulus zeyheri		√W	√W	
Trichodesma africanum			√W	
Viscum rotundifolium		√W	√D,W	
Zygophyllum simplex		√W	√D	

The most important species are viewed as the endemic species (*Barleria lanceoloata*); near endemic species (*Avonia albissima*, *Dactylinadra welwitschii*) and protected species (*Hoodia currorii*, *Sarcocaulon* spp.) (Figures 36-37, 50-51) (Mannheimer 2012).

Figure 50. *Avonia albissima* (near endemic; protected) is often found together with *Lithops* species on quartz gravel plains.

Figure 51. *Dactyliandra welwitschii* (near endemic) is an herbaceous annual vine.

The herbaceous component of the flora increased from 24 species during the dry season to 57 species during the wet season. Herbs observed on hills/ridges, undulating gravel plains and drainage lines habitats increased from 9, 8 and 18 species to 19, 36 and 31 species, respectively. Although not a comprehensive list of herbs known and/or expected to occur in the general area, it does indicate the importance of this flora component in such a dry and marginal environment as well seasonal comparisons.

Invasive alien species

The only invasive alien species observed throughout the ML134 area (other than plants associated with Uis) were a few *Prosopis* spp. (mesquite spp.) individuals associated with the undulating gravel plains and drainage line habitats (Figure 52).

Figure 52. *Prosopis* spp. (mesquite spp.) along a drainage line in the ML134 area.

3.8 Important Species

Reptiles

The high percentage of endemic reptile species (49.1%) associated with the rocky escarpment region of north western Namibia underscores the importance of this area without formal state protection. The most important species expected to occur in the general area (See Table 1) are viewed as the tortoise *Stigmochelys pardalis*; pythons – *P. anchietae* and *P. natalensis*; Namibian wolf snake (*Lycophidion namibianum*) – *Varanus albigularis* and some of the endemic and little known gecko species – e.g. *Pachydactylus* species. Tortoises, snakes and monitor lizards are routinely killed for food or as perceived threats. Another important species is the "rare" – i.e. *Afroedura africana africana* – although very little is known about this species.

Amphibians

The most important species expected to occur in the general area (See Table 2) are viewed as the 4 endemics (*Poyntonophrynus damaranus*, *Poyntonophrynus hoeschi*, *Phrynomantis annectens* and *Tomopterna damarensis*) and especially the 2 species also classified as data deficient (*Poyntonophrynus damaranus*, *Tomopterna damarensis*) by the IUCN (2021).

Mammals

The most important species expected to occur in the general area (See Table 3) are viewed as the species classified as rare in Namibia – i.e. Namibian wing-gland bat and Southern African hedgehog – and vulnerable (cheetah, leopard, Hartmann's mountain zebra, giraffe) and near threatened (African straw-coloured fruit bat, Commerson's roundleaf bat, striped leaf-nosed bat, brown hyena) by the IUCN (2021). Another important and unique species, although not observed, but known to occur in the general area, is the endemic Kaokoland slender or black mongoose (See: Cowley and Cunningham 2004, Warren *et al.* 2009).

Birds

The most important species from the general area (See Table 4) are those classified as endemic to Namibia of which the Damara hornbill, bare-cheeked babbler and Herero chat are viewed as the most important due to the overall lack of knowledge of these species. Although also viewed as important, Rüppels korhaan is migratory throughout its range while the rockrunner inhabits inaccessible terrain and is widespread throughout mountainous areas in Namibia. Other species of concern are those classified as endangered (violet wood-hoopoe, Ludwig's bustard, tawny eagle, booted eagle, martial eagle, black stork) and near threatened (Rűppel's parrot, Cape eagle owl, Verreaux's eagle, peregrine falcon) (Simmons *et al.* 2015) and those species classified by the IUCN (2021) as critically endangered (white-backed vulture), endangered (Ludwig's bustard, lappet-faced vulture, martial eagle, secretarybird), vulnerable (tawny eagle) and near threatened (kori bustard). Although it is not known if vultures (e.g. white-backed vulture, lappet-faced vulture) breed in the area, such nesting sites (including all large raptor nesting sites), should these be established and/or located in future, are viewed as extremely important and should be avoided at all costs.

Flora

Trees/shrubs and Grasses

The most important species from the general area (See Table 6) are viewed as *Acacia montis-usti*, *Adenia pechuelii*, *Aloe dichotoma*, *Caesalpinia pearsonii*, *Commiphora dinteri*, *Commiphora kaokoensis*, *Commiphora kraeuseliana*, *Commiphora saxicola*, *Commiphora virgata*, *Commiphora wildii*, *Cyphostemma currorii*, *Erythrina decora, Manuleopsis dinteri*, *Moringa ovalifolia*, *Sesamothamnus guerichii*, *Sterculia africana*, *Sterculia quinqueloba* and *Welwitschia mirabilis* (See Table 6). However, not all these species are expected to actually occur in the Uis (ML134) area, but rather the larger general area (e.g. *Acacia montis-usti* – Brandberg; *Welwitschia mirabilis* – west/north of Brandberg, etc.).

The most important grasss species from the general area (See Table 7) are viewed as the 2 endemics (*Eragrostis omahekensis*, *Stipagrostis damarensis*), with *S. damarensis* only occurring in the central and northern Namib in dry river courses.

Important plant species known and/or expected from the general Uis area and included in the Red Data Book for Namibia include at least 16 species of which 4 species is listed as rare (*Diclis tenuissima*, *Felicia gunillae*, *Nidorella nordenstamii*, *Pentzia tomentosa*) and 2 species as near threatened (*Adenia pechuelii*, *Lithops gracilidelineata* subsp. *brandbergensis*) (Table 9) (Loots 2005). All the species included in Table 9 are viewed as important.

Table 9. Important species – i.e. Red Data spp. – known to occur in the general Uis area according to Loots (2004).

Species: Scientific name	Conservation status
Adenia pechuelii	Endemic, NT
Aloe dinteri	Endemic, NC, C2, LC
Aloe viridiflora	Endemic, NC, C2, LC
Diclis tenuissima	Endemic, Rare
Dombeya rotundifolia var. *velutina*	Endemic, LC
Euphorbia monteiroi subsp. *brandbergensis*	Endemic, C2, LC
Felicia gunillae	Endemic, Rare
Lithops gracilidelineata subsp. *gracilidelineata*	NC, LC
Lithops gracilidelineata subsp. *brandbergensis*	Endemic, NC, NT
Lithops ruschiorum	Endemic, NC, LC
Namacodon schinzianum	Endemic, LC
Nicotiana africana	Endemic, LC
Nidorella nordenstamii	Endemic, Rare

Pentzia tomentosa	Endemic, Rare
Selago lepida	Endemic, LC
Trema orientalis	LC

Endemic (Loots 2005)
NC – Nature Conservation Ordinance No. 4 of 1975
Rare; NT – Near Threatened; LC – Least Concern (Loots 2005)
C2 – CITES Appendix 2 spp.

Other

Aloes

Aloes are protected throughout Namibia with 2 other aloe species not included in Table 6, but which potentially occur in the general area, and also viewed as important are *Aloe asperifolia* and *A. hereroensis* (Rothmann 2004).

Commiphora

Many endemic Commiphora species are found throughout Namibia with Steyn (2003) indicating that *Commiphora anacardiifolia*, *C. mollis*, *C. crenato-serrata*, *C. multijuga*, *C. oblanceolata* (not included in the Table 6) potentially also occurring in the general area. Craven and Craven (n.d.) also indicate a population of *Commiphora namaensis* in the general Brandberg area. *Commiphora* species have economic potential (i.e. resin properties used in the perfume industry – e.g. *C. wildii*) making them an important species (Knott and Curtis 2006).

Ferns

At least 64 species of ferns, of which 13 species being endemic, occur throughout Namibia. Ferns in the general Uis area include at least 2 endemic species (*Cheilanthes nielsii*, *Isoetes giessii*) and 13 indigenous species (*Actiniopteris radiata*, *Cheilanthes dinteri*, *C. hirta*, *C. marlothii*, *C. parviloba*, *Doryopteris concolor*, *Isoetes aequinoctialis*, *Marselia aegyptiaca*, *M. ephippiocarpa*, *M. vera*, *Ophioglossum polyphyllum*, *Pteris vittata* and *Pellaea calomelanos*) (Crouch *et al.* 2011). The general area is undercollected with more species probably occurring in the general area than presented above.

Hoodia

Hoodia species are protected throughout Namibia with the following expected to occur in the general area: *Hoodia currorii*, *H. gordonii* and *H. pedicillata* (Anon n.d.) (Figure 53).

Figure 53. *Hoodia currorii* were observed as individual specimens on the undulating gravel plains.

Lichens

The overall diversity of lichens is poorly known from Namibia, especially the coastal areas and statistics on endemicity is even sparser (Craven 1998). More than 100 species are expected to occur in the Namib Desert with the majority being uniquely related to the coastal fog belt (Wirth 2010). Lichen diversity is related to air humidity and generally decreases inland form the Namibian coast (Schultz and Rambold 2007). Off road driving is the biggest threat to these lichens which are often rare and unique to Namibia. To indicate how poorly known lichens are from Namibia, the recent publication by Schultz *et al.* (2009) indicating that 37 of the 39 lichen species collected during BIOTA surveys in the early/mid 2000's were new to science (i.e. new species), is a case in point. Lichens are known to occur on rocky terrain in the mountainous terrain in the general area (Figure 54).

Figure 54. Unidentified lichen species observed on rocky terrain in the area.

Lithops

Lithops species – all protected (See Nature Conservation Ordinance No. 4 of 1975) – are also known to occur in the general area and often difficult to observe, especially during the dry season when their aboveground structures wither. The species known to occur in the general Uis area are *Lithops gracilidelineata* var. *gracilidelineata* and *Lithops gracilidelineata* var. *gracilidelineata* subsp. *brandbergensis* (Cole and Cole 2005, Earle and Round n.d.).

Other species with commercial potential that could occur in the general Uis area include *Harpagophytum procumbens* (Devil's claw) – harvested for medicinal purposes and often over-exploited – and *Citrullus lanatus* (Tsamma melon) which potentially has a huge economic benefit (Mendelsohn *et al.* 2002).

3.9 Important Areas

The most important areas in the Uis/ML134 area are:

1. Ephemeral drainage lines

The various larger well vegetated ephemeral drainage lines are important habitat usually with larger, especially protected tree species, including *Acacia erioloba*, *Euclea pseudebenus* and *Faidherbia albida* (See Table 6, Figures 55-57). The most important drainage line is located on the southwestern boundary of the ML134 area (See Figure 57, 61). The drainage line running through Uis is viewed as the second most important drainage line due to being heavily disturbed with various anthropogenic activities while the drainage line on the northeastern boundary of ML134 is even further disturbed with informal settlements adjacent it (Figures 55-56).

Figure 55. The drainage line running through Uis is heavily impacted by various anthropogenic activities with most of the *Faidherbia albida* (anna tree) – protected F – trees either dead and/or dying.

Figure 56. The drainage line running through the northeastern boundary of the ML134 is severely affected by various anthropogenic activities, mainly informal settlement, with most of the trees being felled for fuel.

Figure 57. The well vegetated and most important ephemeral drainage line, including numerous protected tree species, is located on the southwestern boundary of the ML134 (Also see Figure 61).

2. Hills/Ridges

Rocky areas generally have high biodiversity and consequently viewed as important habitat for all vertebrate fauna and flora in the general Uis area. Important tree species include various *Commiphora species* (e.g. *C. gaucescens*, *C. virgata*, *C. wildii*), *Euphorbia virosa*, *Moringa ovalifolia* and *Sterculia africana* (See Table 6, Figures 58-60, 61).

Figure 58. *Sterculia africana* (African star chestnut) – protected F – on rocky terrain at the entrance to Uis from Omaruru.

Figure 59. *Moringa ovalifolia* (phantom tree) – protected F; near endemic – on rocky terrain (including gravel plains) around Uis.

Figure 60. *Commiphora virgata* (slender corkwood) – endemic; protected F – are common on rocky terrain in the general area.

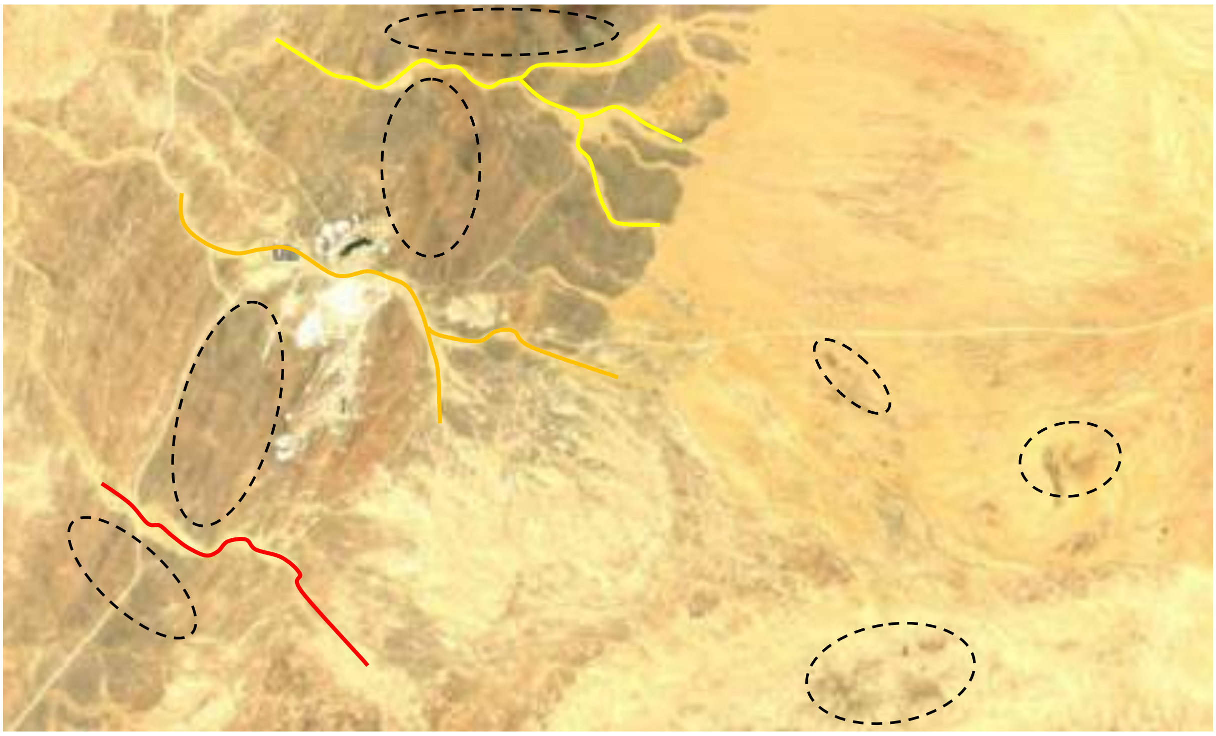

Figure 61. The most important habitats in the Uis/ML134 area are the ephemeral drainage lines (importance ranked from southwest to northeast: red 1st; amber 2nd and yellow 3rd) and the hills/ridges (black dotted oblongs). However, the hills/ridges are not as diverse as elsewhere throughout the western escarpment and affected by various anthropogenic influences, making them less important than if they were in pristine habitat and compared to the ephemeral drainage lines.

4 Envisaged impacts

4.1 Introduction

All developments change or are destructive to the local fauna and flora to some or other degree. Assessing potential impacts is occasionally obvious, but more often difficult to predict accurately. Such predictions may change depending on the scope of the development – i.e. development, once initiated, may have a different effect on the fauna and flora as originally predicted. Thus continuing monitoring of such impacts during the development phase(s) is imperative.

4.2 Faunal disturbance

Faunal disturbance with the proposed mining/exploration activities would be localised. The following table indicates the potential/envisaged impacts expected regarding faunal disturbance (which is obviously closely linked to habitat destruction):

Description	Faunal disturbance will vary depending on the scale/intensity of the development operation and associated and inevitable infrastructure.
Extent	**1.** Mining/exploration site(s) - Localised disruption/destruction of the habitat and thus consequently vertebrate fauna associated directly with the actual sites. This however, would be relatively small areas – depending on scale/intensity of operations – with localised implications. **2.** Mine infrastructure(s) - Localised disruption/destruction of the habitat and thus consequently vertebrate fauna associated directly with the actual sites. This however, would be relatively small areas – depending on scale/intensity of operations – with localised implications.

Duration	**1.** Mining site(s) - The duration of the impact is expected to be permanent at the site(s). This however, would be relatively small area(s) with localised implications. **2.** Infrastructure(s) - The duration of the impact is expected to be permanent at the site(s). This however, would be relatively small area(s) with localised implications.
Intensity	**1.** Mining site(s) - The actual mining site(s) would be permanently altered. This however, would be relatively small area(s) with localised implications. **2.** Infrastructure(s) - The actual construction sites associated with the various mining infrastructures would be permanently altered. This however, would be relatively small area(s) with localised implications. The areas adjacent the mining site(s) and other associated infrastructure should not be significantly affected. This however, would depend on control over the contractors during the road building, construction phase(s) and prospecting/mining phase(s), but should be limited to localised implications. Areas not directly affected by the prospecting/mining and associated infrastructure although within the immediate area would be affected minimally. This would include dust, noise, light and other associated disturbances in the area, but be limited to the prospecting/mining and construction periods.
Mitigation	**General** **1.** Limit the development to actual sites to be mined and avoid affecting adjacent areas, especially mountainous areas and ephemeral drainage lines, throughout the entire area (See Figure 61 & Section 3.9). **2.** Avoid development and associated infrastructure in sensitive areas – e.g. hills and drainage lines in the immediate area (See Figure 61 & Section 3.9). This would minimise the negative effect on the local environment especially unique features serving as habitat to various vertebrate fauna species. **3.** Remove (e.g. capture) unique fauna and sensitive fauna before commencing with the development activities and/or species serendipitously located during this period and relocate to a less sensitive/disturbed sites in the immediate area. **4.** Prevent and discourage the setting of snares (poaching), illegal collecting of veld foods (e.g. tortoises, etc.), indiscriminate killing of perceived dangerous species (e.g. snakes, etc.) and collecting of wood as this would diminish and negatively affect the local fauna – especially during the development phase(s). **5.** Attempt to avoid the removal of bigger trees during the development phase(s) – especially with the development of access routes – as these serve as habitat for a myriad of fauna (See Figures 44, 62). **6.** Prevent and discourage fires – especially during the development phase(s) – as this could easily cause runaway veld fires affecting the local fauna, but also causing problems (e.g. loss of grazing and domestic stock mortalities, etc.) for the neighbouring farmers. **7.** Rehabilitation of the disturbed areas – i.e. initial development access route "scars" and associated tracks as well as associated mining infrastructures. Preferably workers should be transported in/out to the construction sites on a daily basis to avoid excess damage to the local environment (e.g. fires, wood collection, poaching, etc.). Such rehabilitation would not only confirm the company's environmental integrity, but also show true local commitment to the environment.

	8. Prevent domestic pets – e.g. cats and dogs – accompanying the workers during the construction phase as cats decimate the local fauna and interbreed and transmit diseases to the indigenous African wildcat found (and confirmed) in the area. Dogs often cause problems when bonding on hunting expeditions thus negatively affecting the local fauna. The indiscriminate and wanton killing of the local fauna by such pets should be avoided at all costs. **9.** Initiate a suitable waste removal system (i.e. remove to Uis and not store on site) as this often attracts wildlife – e.g. baboons and black-backed jackal, crows, etc. – which may result in human-wildlife conflict issues. **10.** Educate/inform contractors and staff on protected species (See Tables 1 to 7) to avoid and the consequences of illegal collection of such species. **11.** Investigate the idea of employing an Environmental Officer during the construction phase(s) to ensure compliance and minimise the overall impact on the fauna and the environment. **Tracks** **12.** Avoid placing access routes (roads and tracks) trough sensitive areas – e.g. over hills and along drainage lines. This would minimise the effect on localised potentially sensitive habitats in the area. **13.** Avoid driving randomly through the area (i.e. "track discipline"), but rather stick to permanently placed roads/tracks – especially during the construction phase. This would minimise the effect on localised potentially sensitive habitats in the area. **14.** Stick to speed limits of maximum 30km/h as this would result in fewer faunal road mortalities. Speed humps could also be used to ensure the speed limit. Lower speeds would also minimise dust pollution. **15.** Implement erosion control. – i.e. avoid constructing tracks up steep gradients; incorporate erosion furrows (runoff sites) and humps along tracks to channel water off the tracks to minimise erosion problems; cross drainage lines at right angles, etc. The area(s) towards and adjacent the drainage line(s) are easily eroded and further development may exacerbate this problem. Avoid construction within 100m of the main drainage line(s) to minimise erosion problems as well as preserving the riparian associated flora and fauna.
Frequency of occurrence	Expected to be a "once off" issue affecting the selected site(s). Further prospecting and associated road construction (should this become necessary and/or evident during the mining operations) including power line and water pipeline construction activities throughout the area would however increase the frequency of occurrence.
Probability	Definite (100%) negative impact on fauna is expected in the actual mining areas as well as along the access route(s) and infrastructure development sites. This however, would be much localised and cover only a small area(s) and should avoid sensitive areas. Highly Probable (75%) negative impact on fauna is expected in the general areas especially during the construction and mining phase(s) as a result of noise, increased activities, etc. Probable (50%) negative impact on fauna is expected from the infrastructure (roads/tracks/buildings, etc.). Precautionary principle (e.g. avoid unique habitat features as well as adhering to the proposed mitigating measures would minimise this) would decrease the significance of these potential impacts.

Significance	Before mitigation: **High** After mitigation: **Medium** to **Low**
Status of the impact	Negative Localised unique habitats (e.g. drainage lines, hills/ridges) with associated fauna would bear the brunt of this proposed development, but be limited in extent and only permanent at the actual mining site(s) and access routes and infrastructure sites.
Legal requirements	Fauna related: Nature Conservation Ordinance No. 4 of 1975, CITES, IUCN and SARDB Habitat – Flora related: Forest Act No. 12 of 2001, Nature Conservation Ordinance No. 4 of 1975, CITES
Degree of confidence in predictions	As an ecologist I am sure of the above mentioned predictions made and would suggest that the mitigation measures be implemented to minimise potentially negative aspects regarding the local fauna in the area.

4.3 Floral disturbance

Floral disturbance with the proposed mining/exploration activities would be localised. The following table indicates the potential/envisaged impacts expected regarding floral disturbance (which is obviously closely linked to habitat destruction):

Description	Floral disturbance will vary depending on the scale/intensity of the development operation and associated and inevitable infrastructure.
Extent	**1.** Mining/exploration site(s) - Localised disruption/destruction of the habitat and thus consequently flora associated directly with the actual sites. This however, would be relatively small areas – depending on scale/intensity of operations – with localised implications. **2.** Mine infrastructure(s) - Localised disruption/destruction of the habitat and thus consequently flora associated directly with the actual sites. This however, would be relatively small areas – depending on scale/intensity of operations – with localised implications.
Duration	**1.** Mining site(s) - The duration of the impact is expected to be permanent at the site(s). This however, would be relatively small area(s) with localised implications. **2.** Infrastructure(s) - The duration of the impact is expected to be permanent at the site(s). This however, would be relatively small area(s) with localised implications.
Intensity	**1.** Mining site(s) - The actual mining site(s) would be permanently altered. This however, would be relatively small area(s) with localised implications. **2.** Infrastructure(s) - The actual construction sites associated with the various mining infrastructures would be permanently altered. This however, would be relatively small area(s) with localised implications. The areas adjacent the mining site(s) and other associated infrastructure should not be significantly affected. This however, would depend on control over the contractors during the road building, construction phase(s) and prospecting/mining phase(s), but should be limited to localised implications. Areas not directly affected by the prospecting/mining and associated

	infrastructure although within the immediate area would be affected minimally. This would include dust and other associated disturbances in the area, but is limited to the prospecting/mining and construction periods.
Mitigation	**General** **1.** Limit the development to actual sites to be mined and avoid affecting adjacent areas, especially mountainous areas and ephemeral drainage lines, throughout the entire area (See Figure 61 & Section 3.9). **2.** Avoid development and associated infrastructure in sensitive areas – e.g. hills and drainage lines in the immediate area (See Figure 61 & Section 3.9). This would minimise the negative effect on the local environment especially unique features serving as habitat to various vertebrate fauna species. **3.** Remove unique and sensitive flora (e.g. *Aloe* spp., *Commiphora* spp., *Hoodia* spp., etc. – See Table 6) before commencing with the development activities and relocate to a less sensitive/disturbed sites in the immediate area. **4.** Prevent and discourage the collecting of firewood as dead wood has an important ecological role – especially during the development phase(s). Such collecting of firewood, especially for economic reasons, often leads to abuses – e.g. chopping down of live and/or protected tree species such as *Acacia erioloba*, etc. which are good quality wood. **5.** Attempt to avoid the removal of bigger trees during the development phase(s) – especially with the development of access routes – as these serve as habitat for a myriad of fauna. Avoid the destruction of larger trees associated with the ephemeral drainage lines. **6.** Prevent and discourage fires – especially during the development phase(s) – as this could easily cause runaway veld fires causing problems (e.g. loss of grazing and domestic stock mortalities, etc.) for the neighbouring farmers. **7.** Rehabilitation of the disturbed areas – i.e. initial development access route "scars" and associated tracks as well as associated mining/prospecting infrastructures. Preferably workers should be transported in/out to the construction sites on a daily basis to avoid excess damage to the local environment (e.g. fires, wood collection, poaching, etc.). Such rehabilitation would not only confirm the company's environmental integrity, but also show true local commitment to the environment. **8.** Prevent the planting of potentially invasive alien plant species (e.g. *Tecoma stans*, *Pennisetum setaceum*, etc.) for ornamental purposes as part of the landscaping – e.g. office buildings, plant site, access gate, etc. Alien species often "escape" and become invasive causing further ecological damage as is evident from previous human habitation in the area (i.e. invasive aliens on site include *Prosopis* spp., etc. – See Section 3.7). **9.** Eradicate – destroy – all invasive alien plants encountered on site – e.g. *Opuntia*, *Prosopis* spp., etc. – See Section 3.7; Figure 52). This would ensure that the spread is limited and show environmental commitment. **10.** Incorporate indigenous vegetation – especially the protected species e.g. *Aloe* spp., *Commiphora* spp., *Hoodia* spp., etc. – into the overall landscaping. Indigenous species require less water and overall maintenance. **11.** Educate/inform contractors and staff on protected species (See Tables 6-

	9 and Section 3.8) to avoid and the consequences of illegal collection of such species. **12.** Investigate the idea of employing an Environmental Officer during the construction phase(s) to ensure compliance and minimise the overall impact on the flora and the environment. **Tracks** **13.** Avoid placing access routes (roads and tracks) trough sensitive areas – e.g. over hills and along drainage lines. This would minimise the effect on localised potentially sensitive flora and habitats in the area. **14.** Avoid driving randomly through the area (i.e. “track discipline”), but rather stick to permanently placed roads/tracks – especially during the construction phase. This would minimise the effect on localised potentially sensitive flora and habitats in the area. **15.** Stick to speed limits of maximum 30km/h as this would result in less dust pollution. Speed humps could also be used to ensure the speed limit **16.** Implement erosion control. – i.e. avoid constructing tracks up steep gradients; incorporate erosion furrows (runoff sites) and humps along tracks to channel water off the tracks to minimise erosion problems; cross drainage lines at right angles, etc. The area(s) towards and adjacent the drainage line(s) are easily eroded and further development may exacerbate this problem. Avoid construction within 100m of the main drainage line(s) to minimise erosion problems as well as preserving the riparian associated flora and fauna.
Frequency of occurrence	Expected to be a “once off” issue affecting the selected site(s). Further prospecting and associated road construction (should this become necessary and/or evident during the mining operations) including power line and water pipeline construction activities throughout the area would however increase the frequency of occurrence.
Probability	Definite (100%) negative impact on flora is expected in the actual mining areas as well as along the access route(s) and infrastructure development sites. This however, would be much localised and cover only a small area(s) and should avoid sensitive areas. Highly Probable (75%) negative impact on flora is expected in the general areas especially during the construction and mining phase(s) as a result of dust, increased activities, etc. Probable (50%) negative impact on flora is expected from the infrastructure (roads/tracks/buildings, etc.). Precautionary principle (e.g. avoid unique habitat features as well as adhering to the proposed mitigating measures would minimise this) would decrease the significance of these potential impacts.
Significance	Before mitigation: **High** After mitigation: **Medium** to **Low**
Status of the impact	Negative Localised unique habitats (e.g. drainage lines, hills/ridges) with associated flora would bear the brunt of this proposed development, but be limited in extent and only permanent at the actual mining site(s) and access routes and infrastructure sites.

Legal requirements	Flora & Habitat related: Forest Act No. 12 of 2001, Nature Conservation Ordinance No. 4 of 1975, CITES, IUCN, Red Data Book (Namibian plants)
Degree of confidence in predictions	As an ecologist I am sure of the above mentioned predictions made and would suggest that the mitigation measures be implemented to minimise potentially negative aspects regarding the local flora in the area.

Figure 62. Larger and older trees often have cavities which serve as habitat to a variety of vertebrate (and invertebrate) fauna (e.g. cavity dwellers such as bats, geckos, etc.).

5 Conclusion

As all development have potential negative environmental consequences, identifying the most important faunal species including high risk habitats beforehand, coupled with environmentally acceptable mitigating factors, lessens the overall impact of such development.

Vertebrate fauna species most likely to be adversely affected by the proposed mining/prospecting in the Uis/ML134 area would be sedentary species (i.e. species with limited mobility) such as unique reptiles (i.e. tortoises *Stigmochelys pardalis*; pythons – *P. anchietae* and *P. natalensis*; Namibian wolf snake (*Lycophidion namibianum*) – *Varanus albigularis*; some of the endemic and little known gecko species – e.g. *Pachydactylus* species and species viewed as "rare" – i.e. *Afroedura africana africana* – although very little is known about these species). Due to the lack of open permanent surface water, amphibians are not viewed as important in the area although the 2 species classified as data deficient (*Poyntonophrynus damaranus*, *Tomopterna damarensis*) are important. Mammals are more mobile and although important species are known to occur and/or pass through the area (see elsewhere in this report) none are expected to be specifically associated and/or expected to be negatively affected by mining developments. Although general disturbances could affect bird species of concern – i.e. species classified as endangered (violet wood-hoopoe, Ludwig's bustard, white-backed vulture, tawny eagle, booted eagle, martial eagle, secretarybird, black stork), vulnerable (lappet-faced vulture) and near threatened (Rűppel's parrot, kori bustard, Cape eagle owl, Verreaux's eagle, peregrine falcon) – birds are also mobile and not limited to the area.

Flora species most likely to be adversely affected by mining/prospecting would be the various protected species – See Tables 6 and 9; Section 3.9 – although these species are not specifically associated with the Uis/ML134 area.

Seasonal difference (i.e. dry versus wet season observations) in species composition were most evident for the heracious component of the vegetation (See Section 3.7 and Table 8), while an increase in small mammal captures consequently indicate an increase in densities, although not species, during the wet season (See Section 3.3 and Table 4).

Important areas in the general vicinity are viewed as ephemeral drainage lines and hills/ridges – See Section 3.9 and Figure 61. Including the seasonal differences furthermore strengthens the drainage lines and hills/ridges as important habitats in the ML134 area.

It is not expected that further mining/prospecting developments will adversely affect any unique vertebrate fauna and flora in the ML134 area, especially if the proposed recommendations (mitigation measures) are incorporated – See Sections 3.8, 3.9, 4.2 and 4.3 + Figure 61.

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1 November 2021

ECC Environmental
Windhoek
Namibia

For attention: Lester Harker

ARCHAEOLOGICAL ASSESSMENT OF ML 134, ERONGO REGION, NAMIBIA

DECLARATION

I hereby declare that I do:

(a) have knowledge of and experience in conducting archaeological assessments, including knowledge of Namibian legislation, specifically the National Heritage Act (27 of 2004), as well as regulations and guidelines that have relevance to the proposed activity;

(b) perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;

(c) comply with the aforementioned Act, relevant regulations, guidelines and other applicable laws.

I also declare that I have no interests or involvement in:

(i) the financial or other affairs of either the applicant or his consultant

(ii) the decision-making structures of the National Heritage Council of Namibia.

Note: The purpose of this report is to assist the client in gaining consent under the National Heritage Act (27 of 2004) to proceed with mineral exploration and related activities at specific locations as defined herein. The report must always be quoted in full, and not in part, summary or précis form. The report may not be distributed or used for any other purpose by the client, the National Heritage Council of Namibia or any other party and remains the copyright of the author.

John Kinahan, Archaeologist

EXECUTIVE SUMMARY

An archaeological field survey and assessment was carried out on ML 134 in the western parts of Namibia and including the mining settlement of Uis. The lease is situated close to the Dâures massif, or Brandberg, a feature of outstanding archaeological importance. A total of 50 archaeological and historical sites were located in the course of the survey, both within and immediately adjacent to ML 134. The lease has been the focus of mining activity in the past and there is a considerable legacy of impact to the archaeological landscape. However, much of the area is undisturbed and contains a significant concentration of archaeological sites that may require more detailed work in mitigation if mining and related work was to occur in the same vicinity.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Environmental Compliance Consultancy (ECC) is carrying out an environmental assessment of ML 134 held by AfriTin Mining in western Namibia. The lease includes the long-established mining settlement of Uis and lies close to the Dâures massif, or Brandberg, a feature of outstanding archaeological importance. Mining and exploration are listed in the Environmental Management Act (2007) as requiring environmental assessment and the issuance of an Environmental Clearance Certificate.

Archaeological remains in Namibia are protected under the National Heritage Act (27 of 2004) and National Heritage Regulations (Government Notice 106 of 2005), and ECC appointed the undersigned, J. Kinahan, archaeologist, to carry out an assessment of ML 134. A field survey of the lease was carried out between 18th and 23rd October 2021. The following report sets out the results of the survey and an assessment of the of the lease against the background of previous work in the same area.

1.2 Terms of Reference

The primary task of the archaeological assessment reported here was to identify sensitive archaeological sites that could be affected by exploration and mining activities. The archaeological assessment forms the basis of recommended management actions to avoid or reduce negative impacts, as part of the environmental assessment. The study is intended to satisfy the requirements of the relevant legislation and regulations, in which the process of review and clearance may require further, or different mitigation measures to be adopted.

Specifically, the archaeological assessment addresses the following primary elements:

1. The identification and assessment of potential impacts on archaeological/heritage resources, including historical sites arising from the proposed exploration and mining activities.
2. The identification and demarcation of highly sensitive archaeological/heritage sites requiring special mitigation measures to eliminate, avoid or compensate for possible destructive impacts.
3. Formulation and motivation of specific mitigation measures for the project to be considered by the authorities for the issuance of clearance certificates.
4. Identify permit requirements as related to the removal and/or destruction of heritage resources.

1.3 Assumptions & Limitations

Archaeological assessment relies on the indicative value of surface finds recorded in the course of field survey. Field survey results are augmented wherever possible by inference from the results of surveys and excavations carried out in the course of previous work in the same general area as the proposed project, as well as other sources such as historical documentation. Based on these data, it is possible to predict the likely occurrence of further archaeological sites with some accuracy, and to present a general statement (see Archaeological setting, below) of the local archaeological site distribution and its sensitivity. However, since the assessment is limited to surface observations and existing survey data, it is necessary to caution the proponent that hidden, or buried archaeological or palaeontological remains might be exposed as the project proceeds

2. LEGAL REQUIREMENTS

The principal instrument of legal protection for archaeological/heritage resources in Namibia is the National Heritage Act (27 of 2004). Part V Section 46 of the Act prohibits removal, damage, alteration or excavation of heritage sites or remains. Section 48 *ff* sets out the procedure for application and granting of permits such as might be required in the event of damage to a protected site occurring as an inevitable result of development. Section 51 (3) sets out the requirements for impact assessment. Heritage sites or remains are defined in Part 1, Definitions 1, as "any remains of human habitation or occupation that are 50 or more years old found on or beneath the surface".

It is important to be aware that no specific regulations or operating guidelines have been formulated for the implementation of the National Heritage Act in respect of archaeological assessment. However, archaeological impact assessment of large projects has become accepted practice in Namibia during the last 25 years, especially where project proponents need also to consider international guidelines. A document entitled *Archaeological Guidelines for Exploration and Mining in the Namib Desert*[1] has been compiled and widely circulated in the mining community. These guidelines are attached as Appendix 1 to this report. In cases where international guidelines are applicable, those of the IFC, specifically Guidance Note 8: Cultural heritage, are most appropriate. Of these guidelines, those relating to project screening, baseline survey and mitigation are the most relevant.

Archaeological impact assessment in Namibia may also take place under the rubric of the Environmental Management Act (7 of 2007) which specifically includes anthropogenic elements in its definition of environment. The list of activities that may not be undertaken without Environmental Clearance Certificate: Environmental Management Act, 2007 (Govt Notice 29 of 2012), and the Environmental Impact Assessment Regulations: Environmental Management Act, 2007 (Govt Notice 30 of 2012) also apply to the management of impacts on archaeological sites and remains whether these are considered in detail by the environmental assessment or not.

[1] Kinahan, J. (2012) *Archaeological Guidelines for Exploration and Mining in the Namib Desert*.

3. ARCHAEOLOGICAL SETTING

The western parts of Namibia are recognized as a globally important archaeological landscape, having abundant evidence of human settlement spanning the last one million years.[2] Of particular interest and significance are archaeological sites dating to within the last 12 000 years, a period of marked climatic instability that brought many changes in human settlement and subsistence behaviour.[3] This period, the Holocene, commenced with the onset of warm, moist conditions following the Last Glacial Maximum, and saw a rapid expansion of human occupation over the entire Namib Desert. A sudden onset of arid conditions about 5 000 years ago caused a general retreat from the desert, but with a small number of notable exceptions. One of these was the Dâures massif which lies a mere 40km west of ML 134. High elevation and favourable rainfall catchments sustained a refugium habitat suitable for small groups of hunter-gatherers, and systematic archaeological investigations have shown the development of specialized food gathering and processing techniques during this period, as well as the existence of complex social networks maintained by mutual gift exchange. Of major significance is the elaboration of a complex ritual rock art tradition linked to the rise of specialized shamans, or ritual practitioners. During the last 2 000 years, hunter-gatherer communities in this area acquired domestic sheep and pottery, establishing a highly productive semi-nomadic pastoral mode of subsistence.

An essential component of the Namib Desert pastoral economy was the extensive and highly specialized use of wild food plants which were processed to be stored for later use. The most important of these was grass seed obtained from the underground storage caches of harvester ants *Messor denticornis*. The use of these resources enabled desert communities to achieve a measure of food security which seems to have resulted in improved infant survival and a growth in human population during the last two thousand years. The archaeology of these adaptations is subtle and requires detailed analysis of a range of related evidence, including that of pottery, site position and layout as well as isotopic evidence which allows the reconstruction of human diet from skeletal remains. The evidence of settlement in the desert by hunter-gatherer and nomadic pastoral communities tends to be scattered and fragmentary, requiring the recording and investigation of large numbers of small, insubstantial sites. Field survey and analytical methods have been developed in the last few decades of research in this area, to obtain the maximum yield of high precision data from the available archaeological sites. Each new field survey and investigation draws from and builds upon previous work, leading thus to an improved understanding of the regional archaeology.[4]

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[2] Mitchell, P. 2002. *The archaeology of southern Africa.* Cambridge: Cambridge University Press.

[3] Deacon, J. & Lancaster, N. 1988. *Late Quaternary palaeoenvironments of southern Africa.* Oxford: Oxford University Press.

[4] Kinahan, J. 2020. *Namib: the archaeology of an African desert*. Windhoek, University of Namibia Press

4. OBSERVATIONS

A field survey was carried out over ML 134 to locate and document its archaeological features. The terrain is typical of the Namibian central and western plains, with subdued outcrops of Damara schist and Syn- to post-Tectonic granite stocks and bornhardt features, on a landscape otherwise characterized by extensive aeolian sand sheets and alluvial deposits marking the courses of ephemeral streambeds. Rainfall averages about 100mm/$y^{-1}$and vegetation is consequently limited to sparse thorn scrub, except along drainage lines which support narrow margins of riparian woodland.

Figure 1 (A) indicates the known distribution of archaeological sites in the area surrounding ML 134, and Figure 1 (B) shows the contribution of the survey reported here to a more detailed knowledge of the archaeological site distribution. In the field, archaeological sites were located by hand-held GPS, and recorded as to size, estimated age and affinity and then assessed as to their archaeological significance and vulnerability (S/V) using standard parallel scales Table 1). The sites are listed within the report with their location and S/V ranking. Figure 2 shows the distribution of archaeological sites in two age classes, namely recent historical sites (A) and sites of late Holocene age (B).

Table 1: Significance and Vulnerability Ranking of archaeological sites

Significance Ranking		**Vulnerability Ranking**	
0	no significance	0	not vulnerable
1	disturbed or secondary context	1	no threat posed
2	isolated minor find	2	low or indirect threat
3	archaeological site	3	probable threat
4	multi-component site	4	high likelihood of disturbance
5	major archaeological site	5	direct and certain threat

Figure 2 (A) shows the location of sites related to the establishment of the Uis mining settlement after 1946[5]. These sites, listed in Table 2, include four cemeteries and a single (suspected) precolonial grave, as well as historical mine workings and settlement remains. The suspected precolonial grave Site 312/847 is an isolated and slightly dispersed circular cairn approximately 0.8m in diameter. All other cemetery sites on ML 134 were representative of Christian burial and are therefore no older than the late 19th century in this particular area. Site 312/849 is a village cemetery of 22 graves, unfenced. The cemetery sites 312/860 and 312/893 were both fenced and contained an estimated 400 and 100 graves, respectively. The former is currently in use with some graves added within the last year while the latter appears to be fully utilized, and closed.

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[5] Schneider, G. 2004. *The Roadside Geology of Namibia*. Sammlung Geologischer Führer, Berlin: Gebr. Borntraeger.

In addition to these, is Site 312/901, a line of 26 graves located on the south-eastern edge of Uis and adjacent to the main road passing through the settlement. The graves are fenced but unmarked. Local tradition has it that these are the graves of a party of migrant workers who were waiting at this spot for transport to northern Namibia. It is said, although not confirmed, that the group died as a result of eating a meal of meat roasted on a fire of *Euphorbia virosa*, a common local plant containing an irritant latex that is highly toxic to humans and most animals[6]. Other sites relating to the recent history of Uis include workings such as the adits at Site 312/899 and the remains of a mine village with evidence of hand concentrated ore at Site 312/900.

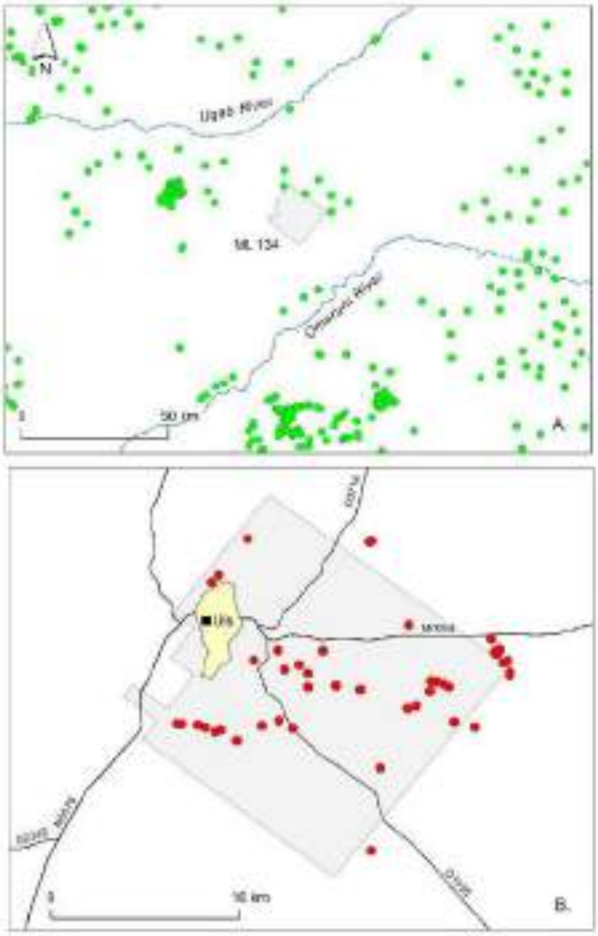

Figure 1: (A) The archaeological setting (green cicles) of ML 134, and (B) the distribution of archaeological sites documented during the present survey (red circles), and showing the location of the Uis mining settlement, the extent of mine works (yellow polygon) and the road network serving the settlement.

[6] Curtis, B. & Mannheimer, C. 2005. *Tree Atlas of Namibia.* Windhoek, National Botanical Research Institute; see also https://en.wikipedia.org/wiki/Euphorbia_virosa

Table 2: Location, description and S/V ranking of historical sites on ML 134

Site	Latitude	Longitude	Description	S/V
Site 312/847	-21,275122	14,855791	1 grave	4/1
Site 312/849	-21,275682	14,8659	22 graves	4/1
Site 312/860	-21,240231	14,925834	>400 graves	4/1
Site 312/893	-21,207755	14,87235	ca 100 graves	4/1
Site 312/901	-21,220642	14,868696	26 graves	4/1
Site 312/899	-21,244841	14,892674	mine adit	4/1
Site 312/900	-21,24009	14,904011	mine village	4/1
Site 312/891	-21,186831	14,889571	village site	4/1

Table 3: Location, description and S/V ranking of archaeological sites on ML 134

Site	Latitude	Longitude	Description	S/V
Site 312/862	-21,241824	15,008651	processing site	4/3
Site 312/863	-21,239756	15,009927	processing site	4/3
Site 312/864	-21,240775	15,007816	processing site	4/3
Site 312/865	-21,241615	15,008244	processing site	4/3
Site 312/866	-21,246063	15,011589	processing site	4/3
Site 312/868	-21,245407	15,013953	processing site	4/3
Site 312/870	-21,250657	15,014971	processing site	4/3
Site 312/871	-21,252104	15,014858	processing site	4/3
Site 312/879	-21,266636	14,970423	processing site	4/3
Site 312/888	-21,187841	14,948679	processing site	4/3
Site 312/889	-21,188036	14,94788	rock art site	4/2
Site 312/890	-21,188408	14,947886	rock art site	4/2
Site 312/859	-21,296417	14,952913	seed digging	2/2
Site 312/867	-21,245466	15,013632	seed digging	2/2
Site 312/872	-21,257318	14,985953	seed digging	2/2
Site 312/873	-21,256074	14,983288	seed digging	2/2
Site 312/874	-21,255154	14,979856	seed digging	2/2
Site 312/875	-21,254849	14,977436	seed digging	2/2
Site 312/876	-21,259511	14,976759	seed digging	2/2
Site 312/877	-21,276687	14,998153	seed digging	2/2
Site 312/878	-21,27412	14,988518	seed digging	2/2
Site 312/880	-21,267855	14,966005	seed digging	2/2
Site 312/881	-21,258709	14,943556	seed digging	2/2
Site 312/882	-21,256762	14,931809	seed digging	2/2
Site 312/883	-21,251094	14,918254	seed digging	2/2
Site 312/884	-21,247003	14,914225	seed digging	2/2
Site 312/885	-21,24949	14,907301	seed digging	2/2
Site 312/886	-21,257448	14,918327	seed digging	2/2
Site 312/887	-21,227909	14,966517	seed digging	2/2
Site 312/892	-21,204248	14,87582	seed digging	2/2

Figure 2: (A) The distribution of historical sites on ML 134, and (B) the distribution of seed digging sites (green squares) documented during the present survey in relation to a group of late Holocene seed processing sites 312/862-871 and a group of mid-Holocene rock art sites 312/888-890.

Figure 2 (B) shows the location of mid- to late Holocene sites on and adjacent to ML 134. These sites, listed in Table 3, include 18 seed digging sites (as described above) spread mainly over the unconsolidated sands and coarse gravel foot-slopes of localized topographic features. Seed digging sites are not considered as sites of archaeological occupation but as reliable indicators of occupation sites within a radius of 4-5km. In present case occupation sites used for the processing of grass seed were located at the eastern extremity of ML 134 where they are concentrated around a complex of small granite bornhardt features (Sites 312/862-871). Fractures and weathered hollows in the rock outcrops form water reservoirs that can hold up to 5m^2 for several months after rain. Seed processing or grinding surfaces are generally found on the same outcrops and an example from ML 134 is shown in Figure 3.

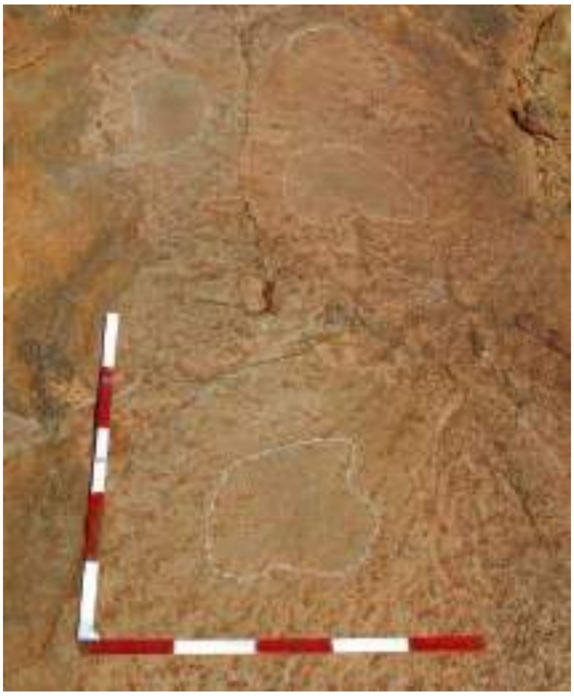

Figure 3: Seed grinding surfaces (circled with white chalk) on a bornhardt feature, ML 134.

Photomicrographs of dental putty impressions from these surfaces reveal parallel and sub-parallel striations caused by the abrasive action of a grinding pestle (see Figure 4), and their association with grass seed is demonstrated by the presence of siliceous phytoliths from cracks in the rock surface[7].

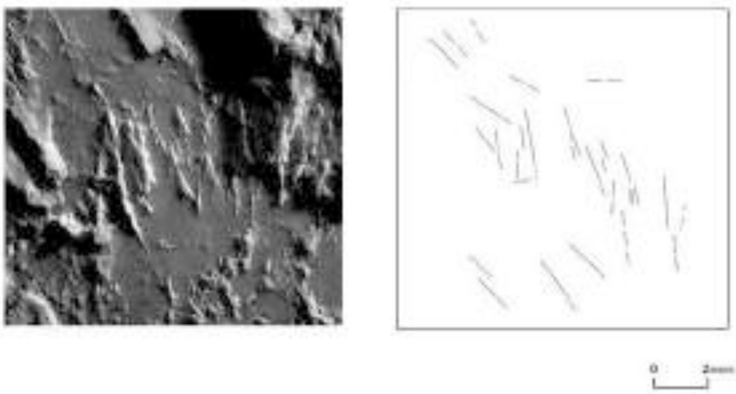

Figure 4: Striations from grinding surfaces on a granite bornhardt.

[7] Kinahan, J. 2020. *Namib: the archaeology of an African desert*. Windhoek, University of Namibia Press, page 239.

The evidence of grass seed exploitation from ML 134 is consistent with a pattern found throughout the Namib Desert and most strongly represented on its eastern fringes and mainly dating to within the last 1000 years. The combination of seed processing sites on rocky outcrops with water sources, and a more widespread distribution of seed digging sites is often associated with a range of other evidence. This would include small homestead groups of huts with storage cairns where processed seed was accumulated in large clay vessels. Other evidence found in the vicinity of these sites might include stone hunting blinds and the remains of scaffold supports at bee's nests in rock crevices. The main focus of the site distribution seen on ML 134 probably lies a few kilometres to the east and well outside the lease area.

Evidence of earlier human settlement in the vicinity of ML 134 consists mainly of occasional scattered stone artefacts, some of late Pleistocene age. A remarkably dense local distribution of mid- to late Holocene sites, mainly stone artefact scatters, is associated with an isolated granite inselberg adjacent to the northern edge of the lease. Sites 312/888-890 (Figure 2 B and Table 3) include two painted friezes, both integral to the stone artefact scatters on the same sites. The scatters have neither pottery nor metal, strongly suggesting an age of about 5000 years when elaborate shamanic art first appeared in this area. Site 312/889 provides a fairly typical example of the shamanic art of this period. Figure 5 shows the setting of the painted frieze within the confines of a small cavity among the rocks, while Figure 6 shows one part of the frieze which seems to depict a row of bundles or of humans in animal skin cloaks, the heads having long since disappeared if as is often the case, these were painted in unstable white pigment.

The seclusion of the frieze within the rock crevice and the paintings themselves conform to the basic principle of occultation which is common to mid-Holocene rock art in this area. Occultation refers to the preparatory stage of shamanic performance when the ritual practitioner disappears from view and then re-emerges to carry out a ceremonial healing or other function. The hidden painting parallels the depiction of the bundles which commonly show ritual participants hidden in animal skin cloaks from which they emerge. Occultation and emergence are the two principal features of a ritual tradition in which the participant disappears into the supernatural realm and then reappears in the familiar world bring with him supernatural powers to heal the sick, or social discord, or to make rain, among many other functions. There is also evidence that the ritual paraphernalia used by the shaman was buried or otherwise hidden when not in use, returning it temporarily to the supernatural realm.[8]

As with the late Holocene seed gathering sites, it is likely that the focal area to which the rock art at Site 312/889 belongs, lies outside the ML 134 lease and probably to the north of it. From these observations it would appear that the Holocene archaeology of the area is unlikely to be affected by exploration and mining activities taking place on the lease.

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[8] Kinahan, J. 2018. A ritual assemblage from the third millennium BC in the Namib Desert and its implications for the archaeology and rock art of shamanic performance. *Azania* 53: 40–62.

Figure 5: The location if the painted frieze at Site 312/889

Figure 6: Dark red-brown monochrome painting of bundles at Site 312/889

5. CONCLUSIONS & RECOMMENDATIONS

The field survey of ML 134 reported here documented evidence of mid and late Holocene settlement as well as more recent evidence mainly in the form of cemeteries associated with the history of the mining settlement at Uis after 1946. The cemetery sites are in this case not of strictly archaeological significance and their conservation would resort under the Burial Place Ordinance (27 of 1966) rather than the National Heritage Act (27 of 2004). The earlier sites fall directly under the protection of the Heritage Act.

Tables 2 and 3 list the sites and co-ordinates together with their archaeological significance and vulnerability (S/V). Significance and Vulnerability ranking of the Holocene sites ranges from a low 2/2 to a relatively high 4/3. However, the Vulnerability ranking may be adjusted when the programme of exploration, and related development is made available. The values only reflect the current situation and would need to be reconsidered and adjusted when exploration activities have advanced further.

It is recommended on the basis of this assessment that the proponent be granted consent to continue with exploration although further investigation of the leases may need to be carried out depending on the nature of the mining programme on ML 134. Mitigation of such activities as may affect protected archaeological sites will require a permit from the National Heritage Council. It is further recommended that the proponent should adopt the Chance Finds Procedure in Appendix 1 as part of the project Environmental Management Plan.

APPENDIX 1

Archaeological Guidelines

for

Exploration & Mining

in the

Namib Desert

John Kinahan

SUMMARY

This handbook is intended to help exploration and mining projects to minimize their impact on the archaeology of the Namib Desert, a unique environment of global importance to the understanding of the human past. A short introduction to the National Heritage Act is followed by an overview of the archaeological evidence, and a description of the most sensitive elements of the archaeological landscape. With this background and a few principles of site management, it is possible to avoid inadvertent damage to archaeological sites. Also included is an outline of the basic standards for archaeological field survey and assessment that are most widely applied in the Namib.

An archaeological landscape in the southern Namib Desert: the basin or playa in the middle distance has dense shoreline scatters of late Pleistocene artefact debris, and the inselberge on the margins of the basin have densely clustered mid- to late Holocene settlement remains including hunting blinds, grave cairns, ritual sites and rock shelters with stratified archaeological deposits.

CONTENTS

Preface

Modern humans and their ancestors have lived in the Namib Desert for more than one million years, leaving a rich legacy of archaeological remains which lie scattered over the landscape. This is by far the longest archaeological record in all the deserts of the southern hemisphere, and it contains unique evidence of how humankind learned to cope with one of the most hostile environments on earth[9].

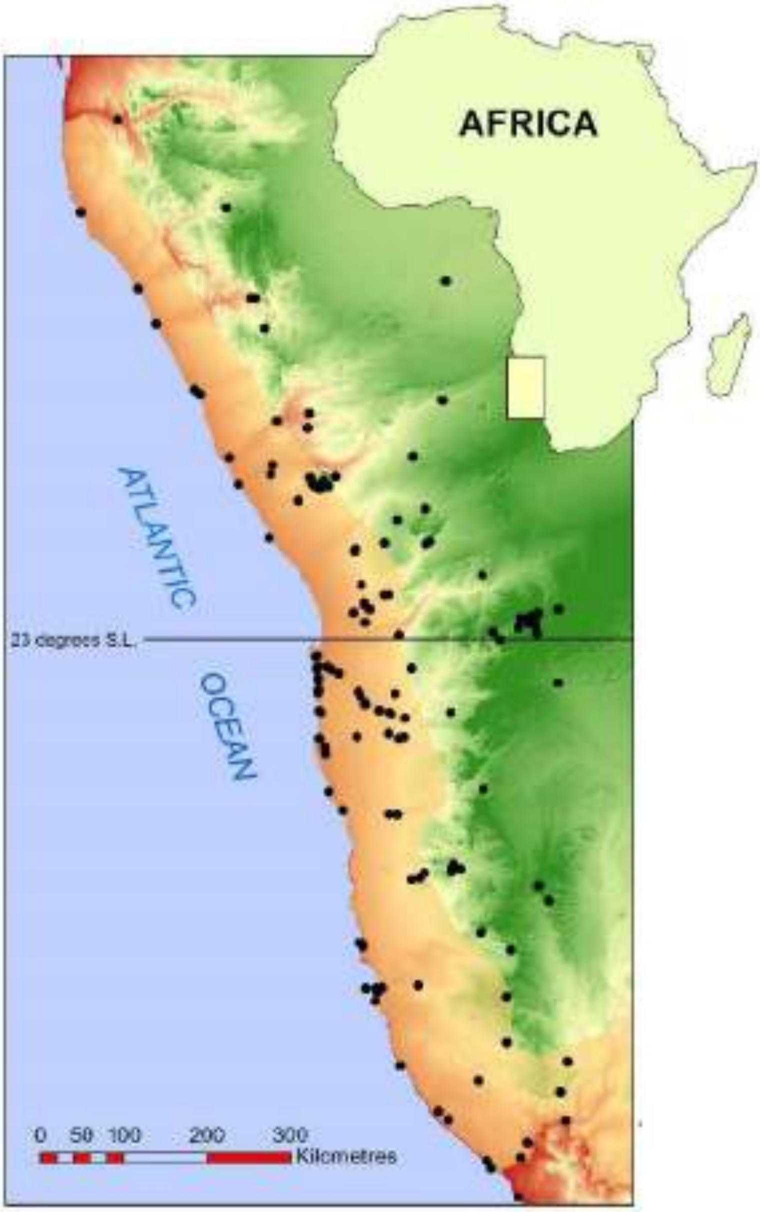
Indigenous communities, the descendants of people who lived in the Namib over thousands of years, still maintain important cultural links with the desert. Much of the Namib is enclosed by national parks and wildlife reserves, but this is no wilderness. Desert plants and animals, and the landscape itself, are an integral part of the cultural heritage of desert communities.

You and I are the most recent visitors to this extraordinary place, but our activities have the potential to cause it irreversible damage. If we do not proceed with caution and consideration, our legacy will be a wasteland of destruction. Of course one cannot build a mine, a road or a power-line without impact, but we can reduce this impact significantly by avoiding unnecessary damage.

It is important to realize that every archaeological site is part of a large and very complex puzzle. Damage to archaeological sites cannot be repaired, and the best way to avoid damaging them is to make sure by means of field survey and assessment, what sites lie in the path of a potential development. Only then is it possible to either conserve the sites or mitigate the impact of development.

This handbook contains simple guidelines for exploration and mining projects, as well as their associated infrastructure. It is based on the premise that we only see what we already know. If this publication helps the geologist, engineer or project manager to see and understand the archaeology of the desert, it may succeed where legislation and policy often fail.

[9] See Mitchell, P. 2002. *The archaeology of southern Africa.* Cambridge University Press, for a general introduction.



The Namib Desert forms a continuous strip 100-150km wide between the Atlantic coast and the escarpment. Here, the desert is shown in light brown, with the escarpment zone in shades of green. During the Last Glacial Maximum, ending approximately 10 000 years ago, the coastline lay up to 100km further west and the desert extended at least 400km into the interior. The black dots are dated archaeological sites.

1. First steps:
the law and best practice

Almost every country has some sort of legislation to protect its cultural heritage, and compliance with these laws is important for any exploration and mining operation. Most large mining companies also have their own cultural heritage policies and procedures to guide their operations and reduce the risk of damaging their reputation.

The principal instrument of legal protection for archaeological sites or remains in Namibia is the National Heritage Act (27 of 2004). Some incidental but nonetheless important protection is provided by the Environmental Management Act (7 of 2007) which includes man-made features in its definition of the environment. Other guidelines include those of the IFC (International Finance Corporation) and the ICMM (International Council on Mining and Metals).

A short guide to the National Heritage Act

The National Heritage Council of Namibia is a statutory body and its work is administered by a Secretariat, based in Windhoek and assisted by a number of specialist committees. All enquiries and applications for permits should be addressed to:

The Director

National Heritage Council

Private Bag 12043

Ausspannplatz

Windhoek

There are as yet no official regulations or guidelines to the Act for exploration and mining projects to consult. The following précis and commentary is intended to indicate and explain some important provisions of the Act. However, it is strongly recommended that exploration and mining project managers obtain legal advice especially with regard to permits.

PART I: In terms of the Act, “heritage” is restricted to places and objects, including those of archaeological, cultural, historical, scientific and social significance. The legislation does <u>not</u> address what is sometimes known as “intangible heritage”, such as customs, beliefs and oral history.

The Act defines “archaeological” as *any remains of human habitation or occupation that are more than 50 years old found on or beneath the surface on land or in the sea*, and especially notes *rock art, being any form of painting, engraving or other representation on a fixed rock surface or loose rock or stone which is 50 or more years old.*

It is important to understand that legal protection can extend beyond the archaeological object or site, to include *the natural or existing condition or topography of land,* as well as the *trees, vegetation or topsoil.*

PART IV: The Council has the responsibility of establishing and maintaining the Namibian Heritage Register which records heritage places and objects. The register is defined as a public document, and project managers may inspect it to determine whether any protected sites lie within their exploration or mining lease area.

However, not all archaeological or other heritage sites qualify for listing in the register. Listing is subject to a prolonged process of approval based on the "heritage significance" of the object or site, and this ultimately involves publication of the site in the *Government Gazette.* Unless there is a listed site, or unless a previously unknown site of high significance comes to light, this part of the Act is of limited concern for exploration and mining projects.

PART V: Damage, disturbance and encroachment on protected sites is strictly prohibited. However, a permit may be granted in some circumstances, and the Council is also empowered to suspend protection of a listed site under some circumstances. This means that protected status is not irrevocable.

Before issuing a permit, the Council may require the applicant to *obtain from a person with appropriate professional qualifications or experience, at the applicant's expense, a statement as to the impact the proposed works and activities may have on the place or object to which the application relates and the risk of damage to the place or object.*

In view of the fact that large areas of Namibia, including much of the Namib Desert, are archaeologically unknown, the precautionary principle dictates that an archaeological survey and assessment should be carried out at an early stage in any large exploration and mining project. Most large mining companies will commission a field survey and assessment as a matter of course.

The Act stipulates that all archaeological assessment, including field surveys, is subject to permits issued by the National Heritage Council. This means that the archaeologist who carries out the survey must be appropriately qualified and in good standing with the authorities.

The appointment of an archaeologist is the prerogative of the project proponent. Best practice requires that the archaeologist should be independent of the National Heritage Council and all other national authorities.

PART VI: All archaeological objects are the property of the State. It is important to note that State ownership extends to all archaeological remains, known or unknown. This means that mining personnel and contractors need to be aware of the legal status of archaeological remains and their legal obligation to report the discovery of any new archaeological remains to the National Heritage Council.

Relevant provisions of the Environmental Management Act

PART I: The definition of the environment employed by the Environmental Management Act (7 of 2007) specifically includes “anthropogenic factors” such as archaeological remains or any other evidence of human activity.

PART II: Environmental impact assessment (EIA) in Namibia is governed by this legislation and usually includes a specialist archaeological survey and assessment, following the stated Principles of Environmental Management which require that *Namibia’s cultural…heritage…must be protected and respected for the benefit of present and future generations.*

In the process of environmental assessment set out in the regulations to the Act there are several stages of consultation, including public participation, preceding the issue of an environmental clearance certificate by the Environmental Commissioner. There is also provision for external review, and an appeal process in the event that environmental clearance is withheld.

Credible environmental assessment must be independent of both the project proponent and the national authority. For this reason environmental assessment, as well as archaeological assessment is not carried out by government institutions and should not include government scientists as specialist consultants.

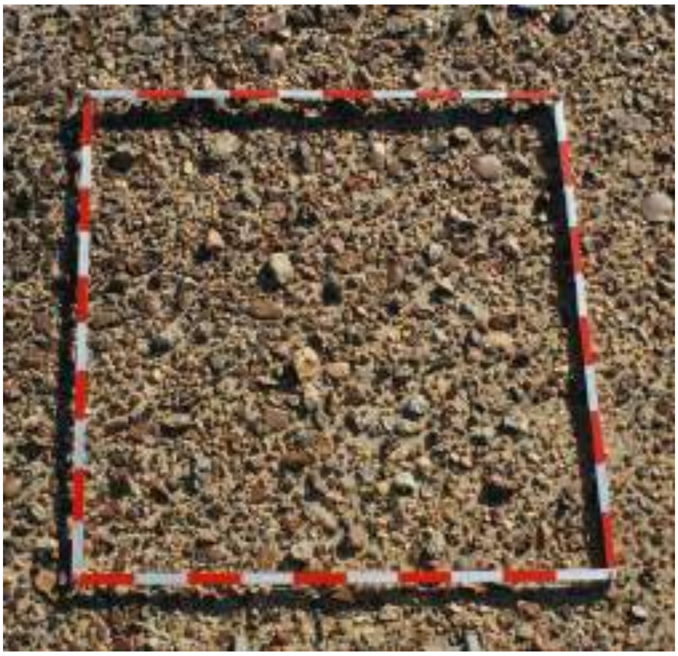
In addition:

The International Finance Corporation (IFC) has specific guidance notes and performance standards applicable to cultural heritage preservation. These standards refer to both tangible forms of cultural heritage, such as archaeological sites and objects, and intangible forms. The standards apply whether or not the archaeological material is protected, and irrespective of whether is may have been previously disturbed. To comply with these standards, a baseline survey and assessment is required.

There are general guidelines issued by the International Council on Mining and Metals (ICMM) and detailed cultural heritage management guidance notes issued by large corporations, for example, Rio Tinto (RT) and Santos. Where such guidelines indicate standards other than the laws of Namibia, their application is subject to group member standards. Best practice in Namibia directly benefits from mining companies with group standards and global experience.

2. Seeing things:
what the archaeological evidence looks like

Human occupation of the Namib Desert in the past was entirely dependent on prevailing climatic conditions, and the climate of the last one million years has been consistently arid, with short periods of higher than usual rainfall. Occupation was therefore sporadic, with long periods in which the desert was unoccupied. Evidence of human occupation is widespread, but thinly scattered. Interpretation of this archaeological record relies on piecing together a large number of fragile and subtle clues[10]. Some of these clues will be easily noticed by the observant field geologist, and noted as an indication that the area might have sensitive archaeological sites.



The most abundant traces of human occupation in the Namib Desert are stone artefacts. These are easily recognized as isolated finds and as surface scatters on the gravel plains of the Namib. Other less common traces include shell middens (usually within less than 5km of the coast), natural rock shelters with evidence of occupation, including rock art, and stone features such as hut circles, hunting blinds and grave cairns. Historical sites include cemeteries, old mine workings, and important traces of World War I military engagements. While some kinds of archaeological sites are highly visible (such as the larger grave cairns), their significance is not obvious. Most archaeological sites in the Namib are difficult for the untrained eye to recognize and most damage to the sites is therefore unintentional.

LEFT: A dense scatter of late Pleistocene artefact debris.

[10] See Deacon, J. and Lancaster, N. 1988. *Late Quaternary Palaeoenvironments of Southern Africa*. Oxford, Clarendon Press; and Kinahan, J. 2011. From the beginning: the archaeological evidence. In Wallace, M. and Kinahan, J. 2011. A History of Namibia. London, Hurst.

ABOVE: A late Pleistocene artefact workshop with chert core flakes and dolerite hammer-stone (pocket-knife for scale). The site is intact and undisturbed after approximately 120 000 years.

Identifying stone artefacts

Stone artefacts were made by removing flakes from a selected core, or block of raw material, using precise blows that leave unmistakeable evidence of human manufacture. Similar breakage patterns very rarely occur in nature. Over time, methods of artefact production became more sophisticated and the different techniques of flaking provide some indication of age[11].

MODE 1: Pebble tool (mid- to late Pleistocene, >500 000 years)

This well preserved example made in fine-grained quartzite was loosely cemented in a conglomerate exposed by recent collapse of a stream bank south of the Omaruru River.

MODE 2: Bifacial hand-axe (late Pleistocene, <500 000 years)

This highly symmetrical tool made in weathered basalt was an isolated surface find on an outwash fan east of Cape Cross. The artefact is 150mm in length.

MODE 3: Blade flake with terminal retouch (end Pleistocene <100 000 years)

This punch-struck blade is 60mm in length. Such artefacts form part of complex toolkits including heavy spear points. Dense scatters of debris are found near outcrops and large nodules of chert.

[11] The modal classification used here is based on Clark, J.D. 1969. *Kalambo Falls prehistoric site Volume 1: the geology, palaeoecology and detailed stratigraphy of the excavations.* Cambridge, Cambridge University Press; this approach is generally applied by Barham, L. and Mitchell, P. 2008. *The First Africans: African archaeology from the first toolmakers to most recent foragers*. Cambridge, Cambridge University Press.

MODE 4: Bladelet flake with slight edge retouch (mid- to late Holocene <5 000 years)

This artefact in crystalline quartz is 15mm in length. Flaking debris on recent Holocene sites is characterized by fragments less than 10mm in length but these are often visible in gravel float. These scatters often contain raw material brought from sources up to 50km away.

Typical stone features sites

Settlements and grave sites are significant and often highly visible features of the archaeological landscape in the Namib. Most of these sites are less than 1 000 years old and they often contain important material evidence of desert subsistence strategies. Grave sites may be construed as evidence of traditional land ownership.

ABOVE: Hut circle within hilltop settlement dated 250 years bp, with shallow archaeological trench on left. Significant soil phosphorus concentrations in such features indicate that they supported wooden frameworks plastered with domestic animal dung.

BELOW: Large grave cairn probably dating to within the last few centuries. These features are usually found isolated from settlement sites, on natural routes across the desert.

The recent past

Visible evidence of early links with the outside world has been found in the course of mining operations on the Namib coast, such as the ca1552AD wreck of the *Bom Jesus*, north of Oranjemund. The intensive trade that developed around Walvis Bay in the 1700s has also left abundant traces, and the desert interior has many sites which document early colonial penetration of the country. Such remains

are often overlooked, or mistaken for modern trash. Glass bottles and trade beads are one of the most enduring types of evidence found in the Namib. The characteristic square “case” gin bottles found in the Namib mostly originated from distilleries in the Netherlands. Early bottles were hand blown and exhibit tell-tale imperfections, while more recent bottles show evidence of technological advances in glass production. Such clues make it possible to accurately estimate the age of bottles, trade beads and other items.

ABOVE: Neck and shoulder fragment of a "case" gin bottle from the distillery of Henkes in Delfthaven, Netherlands, found on the 19th century cattle-droveing route or "Bay Road" across the central Namib. Such items help to identify the overnight camps used on this route.

LEFT: One side of an iron ox shoe from the central Namib. These were commonly used in the mid-19th century, before the German colonial period, when oxen, rather than horses, were preferred as riding animals. The oxen were shoed to cope with long-distance travel in the rocky terrain in the Namib. These items are valuable indicators of the early colonial presence in some remote parts of the desert.

ABOVE: Well preserved waste rock walling around the edges of adits at the late 19th century Annaberg tin mine, near Trekopje.

3. Sensitive places:
where impacts happen

Water was the main limiting factor for human occupation of the Namib, and the distribution of archaeological sites tends to reflect this. However, it is not possible to accurately predict where archaeological sites are likely to occur on this basis alone. The reasons are simple: the availability of water has changed over time and during moist periods people occupied areas that are otherwise dry. In the past, small groups of people could live for many weeks on water trapped in natural rock basins, or by digging for water in drainage lines.

There were other important requirements for human settlement, such as shelter; the availability of edible plants; the movement of game species, and the location of raw material outcrops for stone tool manufacture. Together with all of these considerations people in the Namib had also to deal with competing claims for the same resources: the Namib was a pantry, but it was also a neighbourhood, and archaeologists are interested in trying to understand both the social and the ecological dimensions of life in this environment.

An exploration geologist or project manager who is sensitive to the archaeology of the desert can do a great deal to reduce the impact of exploration and mining because many field surveys have shown that there are particular kinds of terrain that have high concentrations of archaeological sites. Although some kinds of terrain are less sensitive none can be definitively excluded.

Archaeological sites commonly occur in these locations:

OUTCROPS and INSELBERGE: Features ranging in size from minor isolated outcrops to massifs are often associated with archaeological sites because they usually have some surface water and other resources. In most cases, archaeological sites are found only on the foot-slopes of these features, especially where very large boulders provide shelter. These sites may have high concentrations of rock art and stratified occupation deposits.

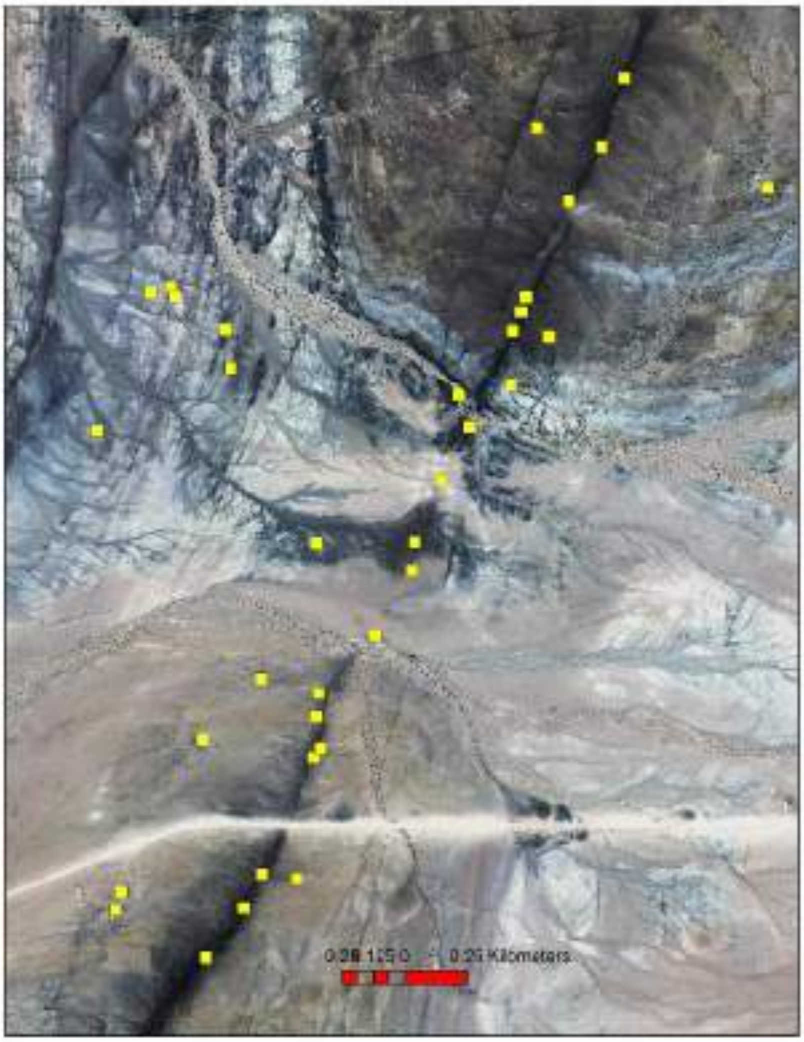
Archaeological sites usually occur in association with smaller outcrops, often so small that they are not indicated on the regional geological mapping. Important outcrop settings for archaeological sites include: early Cretaceous granites, dolerite ridges and sedimentary formations such as the Twyfelfontein (formerly Etjo) sandstones, and localized occurrences of fine-grained quartzite, crystalline quartz and fine- or crypto-crystalline chert. Marble outcrops have relatively few archaeological sites.

SADDLES: Natural routes between drainage basins often pass over low saddles. These locations sometimes have hut circle sites, grave cairns and, occasionally hunting blinds. Hill saddles with archaeological sites can be very minor terrain features, but the more significant examples are easily identified on topographic maps, aerial photographs and satellite imagery.

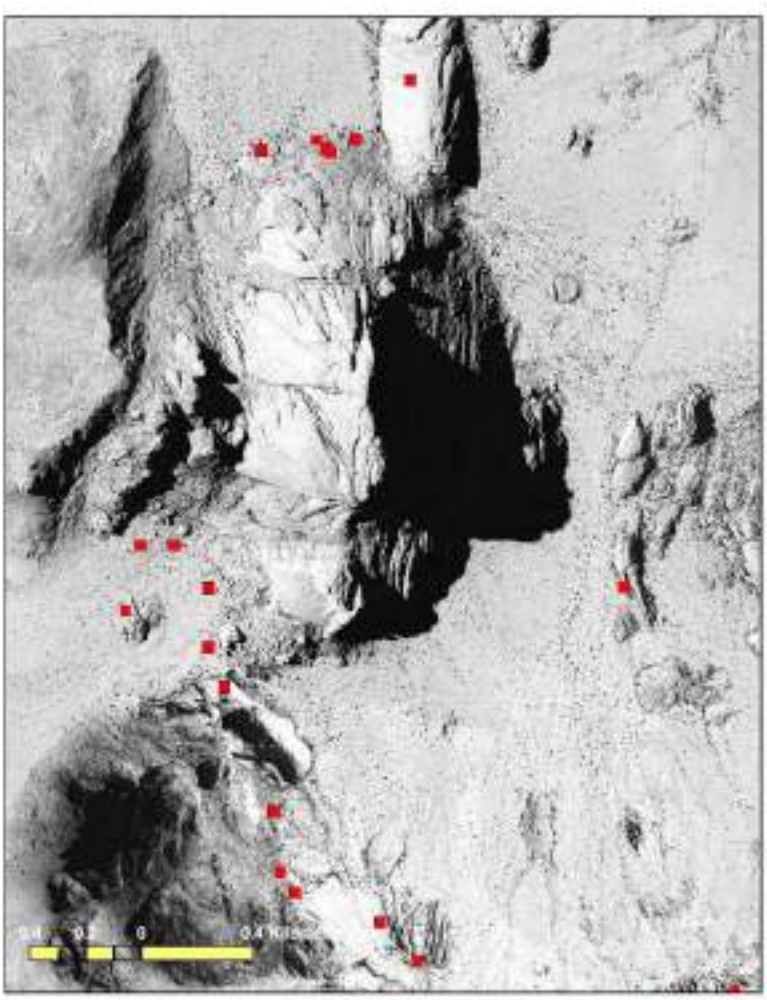
DRAINAGE LINES: River mouths on the Namib coast are invariably associated with shell middens and other archaeological remains. However, because most Namib drainage has a relatively steep gradient, high energy flooding results in extensive reworking of sediments. Outwash fans have relatively few archaeological sites. Older river terraces and over-bank flood deposits provide level and elevated settings that often have archaeological sites.

PANS: Pan-like drainage features in the Namib are subject to occasional flooding and may hold standing water for many weeks. Archaeological sites, mainly stone artefact scatters are commonly found on the strandlines of pans and up to 4km away, after which their density quickly declines. The lee-sides of stable dunes and small outcrops near pans have high archaeological concentrations, Saline pans have relatively few archaeological sites.

DUNEFIELDS and GRAVEL PLAINS: Coastal and near-coastal dunefields, especially those associated with exposed silt deposits (such as the Kuiseb) may have very high concentrations of archaeological sites within reach of water and other resources. Gravel plains in the Namib have highly stable features such as desert pavements, with well preserved and undisturbed artefact scatters.



ABOVE: Typical example showing the close association of archaeological sites with a minor dolerite ridge. The high ridge in the background of the photograph (top) has very few sites compared to the low ridge in the foreground and shown in the satellite image.



ABOVE: Archaeological sites associated with the prominent Spitzkuppe inselberg are primarily on the footslopes among large boulders. Most of the sites are within less than one kilometre of water seepages in the sheet joints of the granite, or rock hollows that retain water after rain.

4: Critical steps in exploration & mining

This chapter considers the archaeological impacts associated with mining activity, and how they might be avoided. Some measures are simple and carry no significant costs. Most impacts can be prevented by identifying archaeological sites in advance and avoiding them where possible. Adopting appropriate measures may save costs and delays, and will certainly enhance the reputation of the company as a responsible corporate citizen.

Relatively few exploration projects result in the development of a mine, but as far as destructive impacts on the archaeology of the Namib are concerned, exploration can result in a disproportionate amount of damage. Much of this damage can be avoided, and even if the project leads to the establishment of a mine it is possible to conserve key archaeological sites right through to the final closure of the mine. To achieve this, it is necessary to adopt key measures at each stage of the project.

Exploration

A pre-fieldwork archaeological assessment is a necessary precaution for exploration in the Namib. There is sufficient field survey data available to allow for an estimation of likely archaeological impacts, even if the exploration area itself has not been surveyed in detail. A pre-fieldwork assessment can form part of the environmental impact scoping study, but it can also be carried out independently to assist with practical planning of exploration fieldwork.

Some prior knowledge of likely archaeological impacts will provide valuable guidance for siting of field camps, access roads, lay-downs for contractors, fuel storage tank farms and various other facilities. The pre-fieldwork assessment can also identify high impact risk areas of the exploration tenement, such as the terrain features discussed in Chapter 3. The pre-fieldwork assessment can be a useful aid to exploration planning by helping to schedule field surveys of sensitive areas before exploration begins on the ground.

As soon as areas of likely archaeological impact have been identified, detailed field survey should be carried out. The elements of field survey are set out in Chapter 5, including data collection and the integration of archaeological spatial data into the exploration programme and area mapping. Here it is important to list the practical precautions required at the exploration stage of the project:

- Use existing access tracks as far as possible; signpost as private all tracks turning off from public roads; observe strict track discipline by employing verge markers, passing points, and clear demarcation at track junctions; avoid establishing new tracks parallel to gradient; rehabilitate redundant tracks for at least 100m from their junction with public roads.
- Field camps and other facilities should be established on archaeologically least sensitive surfaces, such as on drainage lines with naturally rehabilitating substrates. Where practical, temporary structures should be placed on pilings to reduce the development of a permanent footprint. All sensible precautions should be adopted for storage, waste disposal etc.
- All terrain features that are suspected to be archaeologically sensitive should be avoided until they have been surveyed in detail. For example, natural outcrop features should not be used to shelter camps or other facilities; terrain such as hill saddles, pan fringes and outcrop footslopes should be inspected on foot before being entered by vehicle. Highly sensitive sites may be designated as No-Go Areas (see Appendix).

- Personnel and contractors should be informed about the specific archaeological sensitivity of the exploration area, and the relevant terms of the National Heritage Act, through the application of a specific project archaeological management plan (AMP). As soon as baseline archaeological survey data are available these should be consulted on a continuous basis when planning access and exploration activities. Where new archaeological finds are located in the course of exploration, field personnel should observe the Chance Finds Procedure (see Appendix).

ABOVE: Drilling in progress on the central Namib gravel plains. This is an archaeologically sensitive surface and detailed survey should precede drilling.

Development and operation

Ideally, archaeological assessment and mitigation should be completed before development of the mine site commences. This is almost never the case, however, because the process of mine development can require multiple changes in design and layout – with possible implications for sensitive sites. Moreover, development requires infrastructure to link the mine with local road networks, as well as power and water supplies – again with possible implications for sensitive sites, both within and adjacent to the mine licence area. Even the most thorough field survey cannot exclude the possibility that new archaeological discoveries will be made in the course of mine development and operation. To accommodate these needs it is advisable for the mine to adopt a formal archaeological management plan at an early stage in the development process.

THE ARCHAEOLOGICAL MANAGEMENT PLAN (AMP): The purpose of an AMP is to ensure appropriate protection and preservation of archaeological sites through informed decision-making, in line with the law and best practice. The AMP should provide a framework in which management procedures are based on consistent standards and linked to expected outcomes. These procedures should serve as practical guidelines with clearly identified steps and responsibilities. To achieve this purpose, the AMP is accompanied by additional documentation including induction material for personnel and contractors, and detailed background information based on the results of the field survey carried out during the exploration phase.

The AMP should include the following elements:

- A baseline record of sites and remains protected in terms of the National Heritage Act
- A baseline record of mining activity (historical impacts) before and during present operations
- A management system with appropriate decision and risk assessment procedures
- Explicit measures to reduce impacts on known archaeological sites
- Procedures to secure approval for unavoidable disturbance of archaeological sites
- Procedures for the reporting of inadvertent disturbance of archaeological sites
- Measures to enlist the involvement of interested and affected parties in site conservation
- Consideration of indigenous communities' cultural rights in respect of archaeological sites

In principle, the AMP applies to all archaeological sites and remains found within the project licence area, and it applies to all personnel and contractors. It provides a practical means to manage site protection, using a functional and accessible database as a platform for risk management. The AMP is integral to all land disturbance decision-making, and it provides a set of explicit management guidelines to deal with Chance Finds, and management of access to No-Go Areas (see Appendix).

SOME LANDSCAPE PRINCIPLES:

Landscape integrity is often neglected in the planning of mine infrastructure. Coordinated infrastructure planning should aim to minimize fragmentation of the landscape by establishing service corridors (roads, power-lines, pipelines &c), and consolidating infrastructure hubs (pump-stations, pipeline tee-offs, substations, road junctions) wherever possible.

In the Namib Desert surface rehabilitation by raking and other means has become a common practice in the final stages of exploration. This is a largely cosmetic practice, and its long-term benefit to the restoration of desert surfaces has to be weighed against the destructive effect on Pleistocene archaeological sites where raking merely propagates disturbance caused by vehicle tracks. It is therefore essential to integrate archaeological assessment with the rehabilitation programme.

Maintaining areas of archaeological value can provide an important and easily managed offset benefit within the mining licence area. This has obvious advantages: enclosed offset areas are easily managed by the mine because access is controlled; and such areas can provide important archaeological assets to assist the development of alternative land uses (e.g. tourism) after closure of the mine.

The archaeological record in the Namib Desert is a record of highly mobile and temporary settlement. To understand this record, archaeologists adopt a landscape perspective, combining evidence from many sites. Likewise, meaningful conservation of the Namib archaeological record requires a landscape approach, achieved by minimizing fragmentation, especially around areas of especially high significance.

TWO FURTHER POINTS TO REMEMBER: Mining operations, past and present, are part of the archaeological record of human activity in the Namib. It is historical nonsense to attempt to erase this imprint entirely. The remains of mining activity are not only an integral part of the “memory” of the desert landscape, they also provide a valuable physical demonstration of how the desert responds to disturbance and how the scars of human impact persist or vanish over time and under natural conditions. Such demonstration material will become more valuable in future, as impacts and management challenges accumulate. We all know that in physical terms the Namib has a very long memory; it is as well to consider what the legacy of our mining operations will be, and act thoughtfully.

The responsibility of mining companies to the conservation of Namib Desert archaeology extends beyond the mine site, the licence area and related infrastructure. Corporate responsibility and best practice require that mining companies also consider the impact of their personnel in the pursuit of recreation. It makes no sense to scrupulously observe archaeological conservation principles on site and ignore them elsewhere. Archaeological tourism, especially to coastal sites and inland rock art sites is increasingly popular. Mine personnel should consider the impact of uncontrolled archaeological tourism. Recreational use of archaeological sites requires a permit from the National Heritage Council. Tourism operators, both community-based and private should have such permits: *if in doubt ask your tour operator to produce his permit.*

ABOVE: There are many traces of historical exploration and mining enterprises in the Namib Desert. In some cases these may be considered as important cultural heritage assets because there are few written records and few people left to tell us anything about life on small remote mines.

5: Standards
for archaeological survey & assessment

In the absence of official regulations under the National Heritage Act, archaeological assessment in Namibia follows appropriate international best practice. The assessment process, set out in the flow diagram overleaf is based on a conventional three phase approach: a Phase 1 evaluation, usually a desk assessment; a Phase 2 site assessment involving detailed field survey, impact assessment and limited testing; and a Phase 3 mitigation programme, if required. Sometimes Phases 1 and 2 are combined, but Phase 3 is generally separate because it requires prior approval of mitigation measures.

The following notes are not intended as a manual of survey and assessment, but as a guide to the mining company or project proponent as to what the archaeological services to the project might include:

Basic survey requirements

The National Heritage Act stipulates that archaeological assessment should be carried out by a person with appropriate qualifications and experience. The mining company, or project proponent, may appoint an archaeologist of their own choosing. All archaeological fieldwork is however subject to permits issued by the Heritage Council.

Since the Phase 1 evaluation is usually based on literature and database sources, it is very important that the consulting archaeologist has a detailed familiarity with current knowledge and research directions in southern African archaeology. Phase 2 field survey and assessment will require a more detailed familiarity with Namibian archaeology although this is not a prerequisite. Phase 3 is based on mitigation measures approved by the Heritage Council and could be carried out by an archaeologist without local experience.

Best practice requires not only that archaeological survey and assessment should observe legal provisions and standards set out by company guidelines and lending institutions: they should also reflect acceptable standards of archaeological research. This means that the investigation should be based on an explicit methodology; employ standard techniques of field documentation; and provide an assessment that is well founded both in the field evidence presented and in the context of available knowledge.

Archaeological survey and assessment should consider the potential research value of a site, or what is sometimes referred to as the “knowledge dividend”. Conserving a particular site may have a high potential dividend for future research, and this should be taken into account, as would be the potential loss of dividend if the site is damaged or destroyed.

Field methods

Mineral exploration tenements (EPLs) are often very extensive, in excess of 500km^2. Archaeological survey should therefore reflect both the archaeology of the tenement, and place appropriate emphasis on areas of exploration interest. It should therefore be an informed survey in the sense that it considers the terrain context of the archaeology, thus allowing some extrapolation from representative sample areas, and at the same time provide detailed knowledge of areas likely to be affected by exploration. Effective field survey is designed to be representative, informative, and practically feasible.

Some field reconnaissance is helpful in selecting terrain units for survey. The survey itself may be based on transects, random or stratified quadrats, whichever seems appropriate. Site locations should be established by hand-held GPS and plotted in the field on the standard topographic map scale (1: 50 000). The physical setting of the site must be noted, i.e. terrain type, prevailing geology and soil, vegetation cover; the type of site should be noted, i.e. surface scatter, stone feature, rock shelter; the site dimensions should be measured or estimated.

Field survey should include a provisional estimate of the site age, based on characteristic archaeological associations, and a field inventory of the archaeological evidence observed. Any samples collected for identification or analysis should be properly bagged and labelled. All field collecting is subject to permits issued by the National Heritage Council. The site should be photographed if appropriate, both close-up and in context, noting orientation. Further notes and sketches may be added as an aid to interpretation and as a record of any historical site disturbance.

Assessment

Field experience in Namibia has lead to the development of an assessment methodology based on two separate, parallel scales of archaeological *significance* and archaeological *vulnerability*. The two scales consist of interval values from zero to five, and allow the significance of the archaeological site to be considered separately from its vulnerability to disturbance resulting from the project under assessment. Thus sensitivity can be represented as a numerical value based on significance and vulnerability. For example, a site of very high significance that is not vulnerable will have a lower sensitivity value than one that is vulnerable, according to the values assigned on the separate scales. Sensitivity values generated in this way can be adjusted according to project design and brought, though mitigation, to an acceptable level. Note that both significance and vulnerability ranking can change: assessment is subjective and the judgement of the archaeologist may be mistaken or fail to anticipate the future significance of any one find or site.

SIGNIFICANCE RANKING:

0 no archaeological significance

1 disturbed or secondary context, without diagnostic material

2 isolated minor find in undisturbed primary context, with diagnostic material

3 archaeological site forming part of an identifiable local distribution or group

4 multi-component site, or central site with high research potential

5 major archaeological site containing unique evidence of high regional significance

VULNERABILITY RANKING:

0 not vulnerable

1 no threat posed by current or proposed development activities

2 low or indirect threat from possible consequences of development (e.g. soil erosion)

3 probable threat from inadvertent disturbance due to proximity of development

4 high likelihood of partial disturbance or destruction due to close proximity of development

5 direct and certain threat of major disturbance or total destruction

Mitigation

Archaeological mitigation consists in the reduction of a potential threat of destruction, either by timely intervention in the planning and execution of exploration and mining work, to avoid needless impacts, or by investigation or documentation of the site to a sufficient level of detail that its loss or destruction is in some way compensated by the existence of adequate records.

Archaeological survey and assessment will identify the sites and risks of impact that form the basis of a mitigation plan. The mitigation plan submitted to the National Heritage Council must provide sufficient detail for the Council to independently assess the significance of the site and the adequacy of the proposed mitigation measures.

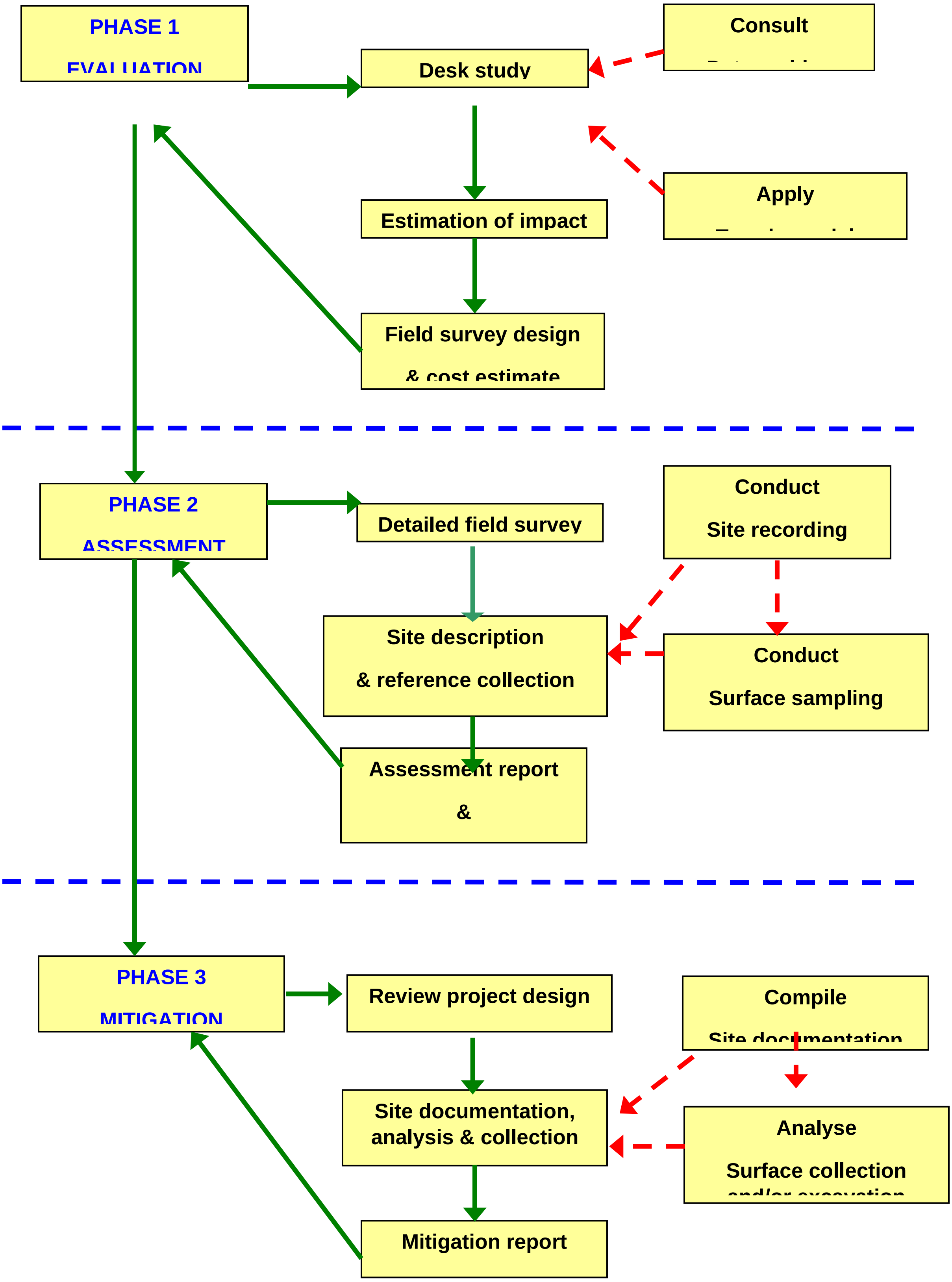
Damage or destruction of an archaeological site is subject to a permit issued by the National Heritage Council. The archaeological survey and assessment process can minimize or even avoid such impacts. In the form of an Archaeological Management Plan (AMP) the results of the survey and assessment will help to minimize or avoid destructive impacts during the operational life of the mine.

Reporting

The structure and layout of archaeological reports may be subject to standard company report templates, but the report should provide a detailed and systematic account of the investigation, with the evidential basis of all inferences clearly set out. The report should be accompanied by digital GIS files including field GPS data, spatial files with attribute tables for the sites, and other files such as sensitivity maps generated from the field survey data.

All reporting of archaeological survey, assessment and mitigation work is the confidential property of the project proponent. In some circumstances, such as mitigation, the National Heritage Council may request part of the investigation results. It is important to note that the project or mine will be the effective custodian of archaeological sites on its lease or licence area. It is therefore very important to consider the vulnerability of archaeological sites and strictly control the distribution of survey data. Site location data should be degraded to a maximum precision of 2.5km before being made available to other parties.

BELOW: Flow diagram illustrating the three phase process of archaeological assessment and mitigation in Namibia. The sequence of steps is indicated with green arrows, and the flow of information from the investigation is shown with dashed red arrows.

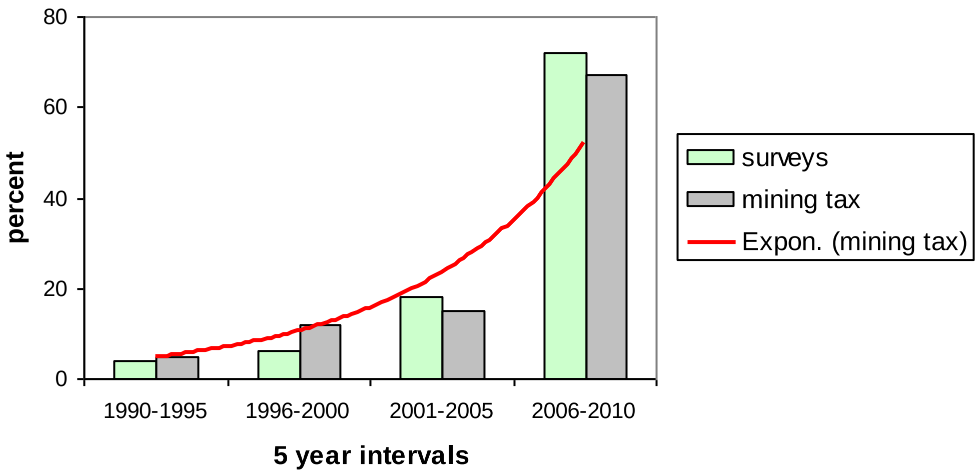

PHASE 1
EVALUATION
Desk study
Consult
Estimation of impact
Apply
Field survey design
& cost estimate
PHASE 2
ASSESSMENT
Detailed field survey
Conduct
Site recording
Site description
& reference collection
Conduct
Surface sampling
Assessment report
&
PHASE 3
MITIGATION
Review project design
Compile
Site documentation
Site documentation,
analysis & collection
Analyse
Surface collection
Mitigation report

6: In the public eye

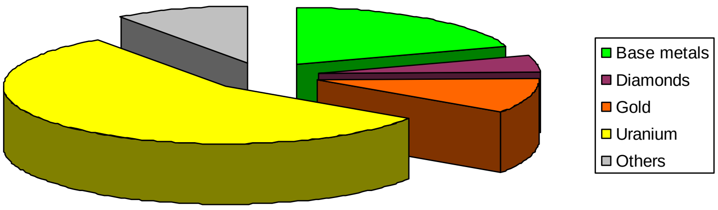
archaeology and the image of the mining industry

During the last two decades, exploration and mining in the Namib Desert have gone well beyond mere compliance with the law, to make a major contribution to furthering archaeological knowledge. On the basis of the accumulated record of archaeological survey from this period, the Namib is among the most intensively surveyed desert regions of the world. However, since nearly all of this survey cover is the result of exploration assessments, it is still patchy and much ground remains to be covered.

There is almost no official funding of archaeological research in Namibia, and survey results from mining and other project assessments represent the largest contributor to field research. The diagram below illustrates the proportionate increase in archaeological survey since Namibian independence, compared to the proportionate increase in taxable mining revenues (non diamond) as an illustration of the growth of archaeological survey in Namibia.

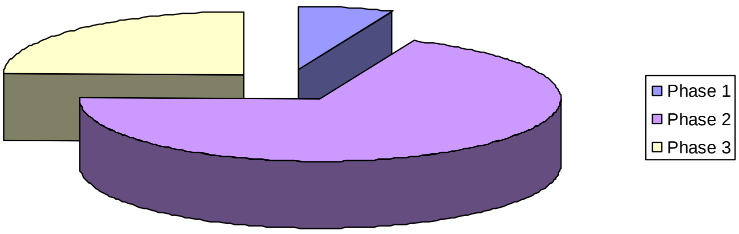


As reflects the general profile of exploration and mining in the Namib Desert, most archaeological surveys (55%) were carried out for uranium projects, followed by base metals (19%), with diamonds, gold and other projects such as dimension stone featuring less prominently. This pattern is likely to change as uranium projects enter the operational stage and exploration for other resources continues.



ABOVE: Relative importance of mining resources to archaeological survey and assessment in the Namib Desert.

The three phases of archaeological survey and assessment are clearly reflected in the record of exploration and mining in the Namib during this period. Phase 1 evaluation, or desk assessment, accounts for a relatively small proportion of archaeological investigation (7%). This may be related to the fact that uranium projects, as the dominant exploration field, combined the Phase 1 and Phase 2 stages in order to establish reliable baseline data. Thus, Phase 2 investigations account for 68% of the total. The fact that Phase 3 mitigation accounts for 25% of the total may reflect the advanced stage of development in a number of uranium projects.



ABOVE: Percentage distribution of archaeological survey and assessment phases in Namib Desert exploration and mining projects.

These simple statistics show that archaeological survey and assessment is an increasingly integral part of exploration and mining in the Namib, that archaeological investigations reflect the general resource profile of the industry in this part of the country, and that most projects accommodate the three phase sequence of archaeological evaluation, assessment and mitigation discussed here.

Beyond compliance with legal and policy requirements there are many opportunities for mining companies to make a contribution to archaeological conservation and education in Namibia. Some sites are suitable for small-scale tourism and could generate local employment and income; others may be used for school or university groups. There is also a need for informative and modern museum exhibitions on the subject of Namib Desert archaeology, and there is a ready demand for both popular and scientific publications on the subject. As mining in the Namib enters a more mature stage in its history it would be appropriate to consider some of these options.

The Namib Desert Archaeological Survey

In the last five years the Namibia Archaeological Trust (est. 1991) has launched a major project to maximize the research potential of archaeological survey and assessment results from the Namib. This project, the Namib Desert Archaeological Survey **http://antiquity.ac.uk/projgall/kinahan325/** has collated all available data to create a common spatial platform; collated all available radiocarbon dating results to provide a single integrated sequence; and adopted uniform standards of site and terrain description to aid regional scale comparative research. The results of the project will appear as a series of research publications, handbooks, and on-line data resources. Some of these are already available at **www.archaeologynamibia.com** The Namib Desert Archaeological Survey would welcome direct support from the mining sector to help it realize some of these goals.

RESOURCES

Namibian legislation

National Heritage Act (27 of 2004) Government Notice 287 29th December 2004

www.archaeologynamibia.com

Environmental Management Act (7 of 2007) Government Notice 232 27th December 2007

www.archaeologynamibia.com

Commencement of the Environmental Management Act, 2007. Government Notice 28 6th February 2012-04-27

www.archaeologynamibia.com

List of activities that may not be undertaken without Environmental Management Certificate: Environmental Management Act, 2007. Government Notice 29 6th February 2012-04-27

www.archaeologynamibia.com

Environmental Impact Assessment Regulations: Environmental Management Act, 2007. Government Notice 30 6 February 2012

www.archaeologynamibia.com

Baseline assessment

Strategic Environmental Assessment for the central Namib Uranium Rush (2011) Windhoek, Ministry of Mines and Energy, prepared by the Southern African Institute for Environmental Assessment

http://www.saiea.com/uranium/index.html

Cumulative effects analysis: Archaeology

http://www.saiea.com/uranium/24Chap7_8March2011.pdf

International conventions & guidelines

Convention concerning the protection of the world cultural and natural heritage. UNESCO 1972. **www.unesco.org**

Cultural heritage management guidance: Rio Tinto Community relations guidance note. Rio Tinto 2007

www.riotinto.com

Good practice guide: Indigenous peoples and mining, ICMM (International Council on Mining & Metals) 2010

www.icmm.com

Guidance note 8: Cultural heritage. IFC (International Finance Corporation) 2007

www.ifc.org

Procedure for the Management of Indigenous Cultural Heritage Sites. Santos Ltd 2007

www.santos.com

Archaeological resources and links

The Namibia Archaeological Trust

www.archaeologynamibia.com

Air Quality Impact Assessment for the Uis Tin Mine in Namibia

Project done for **Environmental Compliance Consultancy (ECC)**

Project Compiled by:
Rochelle Bornman

Project Manager
Hanlie Liebenberg-Enslin

Report No: 21ECC01 | **Date:** September 2022

Address: 480 Smuts Drive, Halfway Gardens | Postal**:** P O Box 5260, Halfway House, 1685
Tel: +27 (0)11 805 1940 | Fax**:** +27 (0)11 805 7010
www.airshed.co.za

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Date	September 2022
Prepared by	Rochelle Bornman, MPhil. GIS and Remote Sensing (University of Cambridge)
Reviewed by	Hanlie Liebenberg-Enslin, PhD (University of Johannesburg)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
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Revision Record

Version	**Date**	**Section(s) Revised**	**Summary Description of Revision(s)**
Draft Rev 0	3 February 2022	Entire report	Submitted for client review
Final Rev 1	6 September 2022	Added Section 5 to the report	Assessed the changes/ additions to the Processing Plant

Abbreviations

ADMS	Atmospheric Dispersion Modelling System
AEB	Atomic Energy Board
AERPA	Atomic Energy and Radiation Protection Act
AfriTin	AfriTin Mining Limited
AQG	Air Quality Guideline
AQMP	Air Quality Management Plan
AQO	Air Quality Objective
AQSR	Air Quality Sensitive Receptor
ASG	Atmospheric Studies Group
ASTM	American Society for Testing and Materials
BFD	Block Flow Diagram
CE	Control efficiency
CERC	Cambridge Environmental Research Consultants
CO	Carbon monoxide
CO_2	Carbon dioxide
CPF	Co-placement facility
DFS	Definitive Feasibility Study
DMS	Dense Medium Separation
EA	Environment Australia
EC	European Commission
ECC	Environmental Compliance Consultancy
EETMs	Emission Estimation Technique Manuals
EF	Emission factor
EHS	Environmental, Health and Safety (IFC)
EQOs	Environmental Quality Objectives
FOE	Frequency of Exceedance
GIIP	Good International Industry Practice
GLC	Ground level concentration
HF	Hydrogen fluoride
H_2SO_4	Sulfuric acid
I&APs	Interested and Affected Parties
IFC	International Finance Corporation
IT3	Interim target 3
ktpa	Kilotonne per annum
Li_2O	Lithium oxide
LMo	Monin Obukhov Length
LoM	Life of Mine
$\mu g/m^3$	Microgram per cubic metre
$mg/m^2/day$	Milligram per metre squared per day
m/s	Metres per second

MHCP	Materials handling and concentrating plant
Mtpa	Megatonne per annum
MSF	Metallurgical Support Facility
NO_2	Nitrogen dioxide
NOx	Nitrous oxide
NPi	National Pollutant Inventory (Australia)
O_3	Ozone
Pb	Lead
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5μm
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10μm
ROM	Run-of-Mine
SA NAAQS	South African National Ambient Air Quality Standards
SA NDCR	South African National Dust Control Regulations
SEMP	Strategic Environmental Management Plan
Sn	Tin
SO_2	Sulfur dioxide
SoW	Scope of Work
Ta	Tantalum
TSP	Total Suspended Particles
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTMC	Uis Tin Mining Company
VOC	Volatile Organic Compounds
WBG	World Bank Group
WHO	World Health Organisation
WRD	Waste rock dump
WRF	Weather Research and Forecasting

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Compliance Consultancy (ECC) to undertake a specialist air quality impact study for the proposed Phase 1 Fast-Tracked Stage II expansion of the Uis Tin Mine (hereafter referred to as the Project).

Air pollutants will derive from opencast operations at two pit areas (V1 and V2 open pits) and the associated processing operations. Ore and waste will be removed with haul trucks and taken to the Run of Mine (RoM) stockpile area and waste rock dump (WRD)/Co-placement facility (CPF), respectively. Ore will be crushed at a primary crusher whereafter it will undergo secondary crushing, fines crushing and milling at the processing plant. The waste from the processing plant will be hauled to the CPF. Ore production is currently estimated at 567 kilo tonnes per annum (ktpa); this will increase to 850 ktpa to support the expanded materials handling and concentrating plant (MHCP) capacity.

The main objective of the air quality specialist study was to determine the potential for dust on the surrounding people and environment, and to provide practical mitigation measures on how to reduce the potential impacts.

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the air quality legislative and regulatory context, including ambient air quality guidelines.
3. A study of the receiving (baseline) environment, including:
    a. The identification of AQSRs from available maps and field observations;
    b. A study of site-specific atmospheric dispersion potential by referring to available weather records, land use and topography data sources;
    c. The identification of existing sources of dust emissions at and around Uis;
    d. The characterisation of existing ambient air quality at and around Uis based on available ambient monitoring/modelling data (if available); and
    e. Analysis of dustfall monitoring data collected by Uis Tin Mine.
4. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Atmospheric dispersion simulations to determine ground level air concentrations (GLCs) and fallout levels as a result of the Project.
    c. The screening of GLCs and fallout levels against environmental air criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist air quality impact assessment report.

Baseline characterisation

The Uis Project is located near the town of Uis, approximately 164 km north of Swakopmund and 30 km northwest of the Brandberg mountain, Namibia’s highest mountain (2 559 m above sea level). The closest residential developments to the Project consist of Uis (~1.9 km to the northwest), Uis Mining Village (~1.7 km to the east) and Tatamutsi (~3.4 km to the east). Individual farmsteads also surround the Project area.

On-site meteorological data was not available. Use was made of Weather Research and Forecasting Model (WRF) simulated meteorological data for the period 2018 – 2020 for a location at the mine.

The baseline characterisation can be summarised as follows:

- The wind field in the area is dominated by winds from the southwest during the day and night, with an increase in winds from the south-southwest and south during the night. Day- and night-time average wind speeds are 4.6 m/s and 5.0 m/s respectively. Calm conditions occur 3.0% of time during the day and 2.5% during the night. On average, air quality impacts are expected to be slightly more notable to the north and north-east of the Project.
- The predominant south-south-westerly, southerly and north-north-easterly winds in the study region may be explained by the topography of the study area. Uis is ~800 m above sea level with the highest point at 900 m above sea level. The terrain is fairly flat in the immediate vicinity of the plant site, with steeper and higher relief areas confined to the northeast and south. The highest wind speeds (more than 6 m/s) were recorded during summer and springtime and are mostly from the south-southwest and southwest.
- Maximum, minimum, and mean temperatures were given as 39.9°C, 1.2°C and 22.5°C respectively from the WRF data for the period Jan 2018 to Dec 2020.
- Average annual rainfall at Uis town for the period 2009 to 2021 was given as 656 mm, with most rain recorded during the summer (December to March) and least during the winter months from May to September.
- The main pollutant of concern in the region is particulate matter (TSP; PM_{10} and $PM_{2.5}$) resulting from vehicle entrainment on the roads, windblown dust, mining and exploration activities.
- Sources of atmospheric emissions in the vicinity of the Project include small-stock farming, small-scale mining, activities of the Namclay Brick and Pavers factory, dust generated from historically mined areas and, to a lesser extent, emissions from vehicle tailpipes along the C36 and D1930 public roads. Other regional sources that may have an influence on the ambient air quality around the Project are biomass burning (natural bush fires or those employed for agricultural purposes) and de-bushing to increase the grazing capacity of farmland. Given these activities, it is expected that fugitive dust may be present during dry, windy conditions. However, the contribution of all these sources to existing ambient air quality is considered very low, especially in a low-density population area such as the one where the Uis mine is located.
- Regional scale transport of mineral dust and ozone (due to vegetation burning) from the north of Namibia is a potential contributing source to background PM concentrations.
- There is no ambient air quality data available for the study site. PM concentrations measured as part of the SEMP AQMP monitoring network were limited to the coastal towns of Swakopmund, Walvis Bay and Henties Bay with a station in the central western part of the region on the farm Jakalswater. None of these locations are representative of the air quality in the Uis area.
- Dustfall monitoring data was provided for the period March 2019 to August 2021. The monitoring network comprised of eight (8) single dustfall units between March 2019 and November 2020 but has been expanded to fourteen (14) single dustfall units from December 2020 forward. Dustfall rates were generally low for the sampling period and well within the dustfall limit of 600 mg/m²/day (adopted limit for residential areas) and 1 200 mg/m²/day (adopted limit for non-residential areas), with the exception of AQ 01 (5 exceedances in 2020 and 4 exceedances in 2021), AQ 05 (2 exceedances in 2019, 5 exceedances in 2020 and 1 exceedance in 2021), AQ 08 (1 exceedance in 2019) and AQ 14 (1 exceedance in 2020).

Impact Assessment

Emissions due to the construction of the secondary crushing and screening plant as well as the Dense Medium Separation (DMS) feed stockpile were quantified using area-wide emission factors for general construction activities. A quantitative air quality impact assessment was conducted for the operational phase activities of the Uis project. The assessment included an estimation of atmospheric emissions, the simulation of pollutant concentrations and determination of the significance of impacts.

The impact assessment was limited to airborne particulate (including TSP, PM_{10} and $PM_{2.5}$). Gaseous emissions (i.e. SO_2, NOx, CO and VOCs) were not included and will primarily result from diesel combustion and from mobile and stationary sources.

Construction Phase

- The construction phase during Stage II was designed to allow pre-assembly while the plant is in operation. Construction work include civil works, in-plant erection, piping, erection of conveyors and gantries, conveyor mechanical installation, and electrical, control and instrumentation work. The largest construction works (in terms of land area) are the construction of a new secondary crushing and screening plant and a DMS feed stockpile. The total land area was determined from georeferenced site plans as approximately 1 320 m^2.
- Using US-EPA emissions factors for general construction activities, and assuming that the quantity of dust emissions is proportional to the area of land being worked and the level of construction activity, construction emissions were estimated at 355 kg for TSP, 138 kg for PM_{10} and 69 kg for $PM_{2.5}$.
- Due to the intermittent nature of construction operations, construction impacts are expected to have a small but potentially harmful impact at the nearest AQSRs depending on the level of activity. With mitigation measures in place these impacts are expected to have **minor** significance.

Operational Phase

- Two mining scenarios were assessed to determine the increase in impacts due to the Project, namely a Baseline scenario and Project Scenario. It was assumed that Stage I throughputs as provided in the Definitive Feasibility Study (DFS) summary represent the Baseline scenario (current mining rates) and that Stage II throughputs represent the Project scenario (future mining rates required to support the expanded MHCP). V1 and V2 opencast areas were assumed to be mined concurrently in a 57:43 tonnage split.
- Emissions quantified for the Uis Project were restricted to fugitive releases (non-point releases) with particulates the main pollutant of concern. Emissions were quantified based on provided information on mining rates and mine layout plan.
    - Quantified PM_{10} and $PM_{2.5}$ emissions were similar for unmitigated Baseline and Project operations. TSP emissions were higher for the unmitigated Project Scenario. Quantified PM_{10}, $PM_{2.5}$ and TSP emissions were higher for design mitigated Project operations than its counterpart Baseline operations, apart from crushing activities (due to the high control efficiency of the dual scrubber on the primary and secondary crushers for the Project Scenario).
    - The main sources of controlled $PM_{2.5}$, PM_{10} and TSP emissions due to the Project scenario are, in order of importance: i) in-pit operations (including in-pit haul roads, materials handling and drilling), ii) vehicle entrainment from unpaved surface roads, iii) wind erosion from the WRD, CPF and ROM stockpiles, iv) crushing and screening (primary; secondary, tertiary and fines) operations, v) materials handling and vi) blasting, with blasting a lesser source due to its intermittent nature and variable duration.

- For each of the two scenarios, unmitigated and mitigated options were modelled. Mitigation was applied based on design mitigation measures provided, which included the following:
    - in-pit haul roads: water sprays assuming 50% control efficiency (CE);
    - surface haul roads: water sprays assuming 75% CE;
    - crushing and screening of ROM (primary and secondary): assuming 99% CE for dual scrubber;
    - crushing and screening of ROM (tertiary and fines): assuming >75% CE for wet processes; and
    - materials handling, including conveyor transfer: assuming 50% CE for water sprays.

- Dispersion modelling results for the Baseline Scenario:
    - PM_{10} daily GLCs, for unmitigated activities, result in exceedances of the 24-hour air quality objective (AQO) over a maximum distance of ~700 m from Uis mining activities, but with no exceedances at any of the AQSRs. For mitigated activities, impacts are limited to the Uis mining and processing plant areas with no exceedances at any of the AQSRs. PM_{10} annual GLCs, for both unmitigated and mitigated activities, are within the AQO at the AQSRs.
    - $PM_{2.5}$ daily GLCs, for unmitigated activities, do not exceed the AQO (WHO IT-3) at any of the AQSRs but the footprint of exceedance extends ~300 m off-site. For mitigated activities, there are no exceedances at any of the AQSRs and impacts are limited to on-site areas. There are no exceedances of the annual $PM_{2.5}$ AQO, without and with mitigation in place.
    - Maximum daily dustfall rates, for both unmitigated and mitigated activities, do not exceed the AQO (SA NDCR residential limit of 600 mg/m²/day) at any of the AQSRs.

- Dispersion modelling results for the Project Scenario:
    - The daily PM_{10} AQO (WHO IT-3 and SA NAAQS) is exceeded over a maximum distance of 950 m from the Uis mining area (with no mitigation in place) but reduce to smaller areas of exceedance on-site when mitigation is applied. PM_{10} daily GLCs, for unmitigated and mitigated activities, do not result in any exceedances of the 24-hour AQO at the AQSRs. Over an annual average there are no exceedances at any of the AQSRs, without and with mitigation.
    - For daily $PM_{2.5}$ the area of maximum unmitigated GLCs exceedance extends northwest from the Uis mining operations over a maximum distance of ~750 m, with no exceedances at any of the AQSRs. With mitigation in place there are no exceedances at any of the AQSRs and the impact is reduced to much smaller areas of exceedance. Annual average $PM_{2.5}$ GLCs are low at all AQSRs.
    - Maximum daily dustfall rates, for both unmitigated and mitigated activities, are within the AQO (SA NDCR residential limit of 600 mg/m²/day) at all of the AQSRs.

- For both the Uis Baseline and Project Scenarios, the significance is expected to be **minor** with and without mitigation in place.

- Cumulative air quality impacts could not be assessed since no background PM_{10} and $PM_{2.5}$ data are available. The localised PM_{10} and $PM_{2.5}$ impacts from the Uis modelling results indicate the potential for low regional cumulative impacts, resulting in **minor** significance.

Subsequent to the initial impact assessment (referred to as the Project), additional changes will be made to the processing operations including a bulk sampling and ore sorting and testing facility (referred to as the Petalite Beneficiation Plant) to extract the lithium-bearing ore.

- Two operational scenarios were assessed, namely the incremental and cumulative Petalite Beneficiation Plant scenarios, each with an unmitigated and mitigated sub-scenario.

- Emissions for the Petalite Beneficiation Plant were quantified based on provided information on processing rates and plant layout.

- Drying and Classifying is the main source of PM_{10} and $PM_{2.5}$ emissions from this process, followed by unpaved roads for PM_{10} and crushing and screening for $PM_{2.5}$. The main source of TSP emissions is crushing and screening, followed by unpaved roads.

- Dispersion modelling results for the incremental Petalite Beneficiation Plant
  - Simulated values for PM_{10}, $PM_{2.5}$ and maximum daily dustfall rates at AQSRs are negligibly small.
  - PM_{10} and $PM_{2.5}$ daily GLCs, for unmitigated activities, result in exceedances of the 24-hour air quality objective (AQO) over a maximum distance of ~90 m from on-site activities.
  - The footprint of exceedance of maximum daily dustfall rates exceed the AQO within 125 m from the facility's activities.
- Cumulative air quality impacts (the Project and the Petalite Beneficiation Plant)
  - The cumulative plots including the Petalite Beneficiation Plant are not significantly different from those for the Project Scenario. The numerical results simulated at the AQSRs are also not significantly different from those simulated for the Project only. It may therefore be concluded that the conclusions from this report would not change as a result of the Petalite Beneficiation Plant.

Conclusion

The proposed Uis Project is not likely to result in $PM_{2.5}$ and PM_{10} ground level concentrations in exceedance of the selected AQOs at any of the AQSRs, for both unmitigated and mitigated activities. Impacts due to unmitigated activities are likely to extend over a localised area around mining activities. With mitigation in place, the resulting impacts can be limited to on-site areas. Dustfall rates are likely to be low throughout the life of mine.

It is the specialist's opinion that the proposed project could be authorised provided strict enforcement of mitigation measures and the tracking of the effectiveness of these measures to ensure the lowest possible off-site impacts.

Recommendations

The most practical approach in controlling PM emissions would be the application of water sprays where and as often as possible. Other measures are also proposed. These include:

- Construction phase:
  - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks; limiting unnecessary travelling of vehicles on untreated roads; and applying water suppression to achieve a control efficiency (CE) of 75%.
  - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
- Operational phase:
  - Control of vehicle entrained dust with a CE of 75% on unpaved surface roads through water suppression, and water sprays on the in-pit haul roads, to ensure a 50% CE.
  - In controlling dust from crushing and screening operations, it is understood that the primary and secondary crushers will achieve 99% CE by using a dual scrubber, whereas plants that use wet suppression systems and use spray nozzles can effectively control PM emissions due to tertiary/fines crushing and screening (achieving upwards of 75% CE).
  - Mitigation of materials transfer points should be done using water sprays at all tip points. This should result in a 50% control efficiency. Regular clean-up at loading points is recommended to avoid re-entrainment.

- Minimising windblown dust from the CPF and WRDs can be done through through vegetation on the CPF side walls and keeping the dried-out areas at the CPF wet, and vegetation cover on the side walls of the WRDs.
- Controlling dust from Drying and Classifying can be done using fabric filters. This should result in 90% CE.

- Air Quality Monitoring:
  - The current dustfall monitoring network, comprising of fourteen (14) single dustfall units, should be maintained and the monthly dustfall results used as indicators to track the effectiveness of the applied mitigation measures. Dustfall collection should follow the American Society for Testing and Materials (ASTM) method.

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1 INTRODUCTION

AfriTin Mining Limited ("AfriTin") is the owner of the Uis Tin Project[1] in Namibia. The Uis Tin Mine infrastructure development commenced in 2018 and is located near the town of Uis, approximately 164 km north of Swakopmund (Figure 1). AfriTin received a mandate to develop the Uis Tin Project in Namibia through two phases (AfriTin Mining, 2021):

- Phase 1: Development of a pilot mining and processing facility, exploration drilling, and the completion of a bankable feasibility study for the final mine configuration.
- Phase 2: Construction of the final mine configuration to mine and process 3.1 Mega tonnes per annum (Mtpa) ore to produce 5 kilo tonnes per annum (ktpa) of saleable tin concentrate.

Phase 1 is to be implemented across four stages (AfriTin Mining, 2021):

- Stage I: Achieve steady-state production. The commissioning of the Phase 1 processing plant commenced in August 2019. Plant throughput has increased steadily month-on-month, although current production remains below the design capacity. Debottlenecking of the plant, combined with various other initiatives to improve availability and utilisation, support the ramp-up to the original steady-state production targets.
- Stage II: Increase production capacity and recovery by:
    - increasing throughput capacity by 50% from 80 tph to 120 tph, which can be achieved by modular expansion of individual circuits;
    - improving overall recovery of tin (Sn) from 60% to 70% by adding comminution and beneficiation capacity for tailings streams in the concentrator, which are currently discarded; and
    - improving overall recovery of tantalum (Ta) from 15% to 30% by optimising liberation between the tin and tantalum bearing minerals and improved magnetic separation efficiency.
- Stage III: Introduce second by-product by adding a circuit to produce a petalite concentrate at 4% Li_2O to sell into the glass and ceramics market.
- Stage IV: Further expand tin and tantalum concentrate production by increasing average concentrator plant feed tin grade from 0.139% to 0.158% through implementation of an automated ore-sorting circuit after the first two crushing stages to reject barren pegmatite before the final stages of comminution and then concentration.

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Compliance Consultancy (ECC) to undertake a specialist air quality impact study for the proposed Phase 1 Fast-Tracked Stage II expansion of the Uis Tin Mine (hereafter referred to as the Project).

The Phase 1 Fast-Tracked Stage II expansion includes the following changes to the process flow in various sections of the plant:

- A secondary crusher and screen are added between the primary jaw crusher and the fines crushing section.
- A stockpile is added as a buffer between the crushing and concentrating sections.
- Water rejection capacity is increased in the Dense Medium Separation (DMS) 1 section.
- The medium circuits for DMS 2 and DMS 3 are combined to improve operability of DMS 3 and maximise tin recovery from DMS 2 floats after further liberation.
- The DMS 2 floats re-crush circuit is converted to a closed circuit by adding a classification screen in the circuit. In addition, feed is added before the roll crushers to improve operability.
- Additional spirals to re-process middlings are installed in the spiral plant.

[1] The Uis tin mine is a historical mine that was owned and operated by Imkor Tin, a subsidiary of Iscor South Africa. Mining commenced in 1958, and the operation was closed in 1991 (Maritz and Uludag, 2019).

- The product handling infrastructure is relocated, and an additional shaking table is installed to improve capacity. The existing Wilfley shaking tables are replaced with Holman tables for higher separation efficiency.

The Phase 1 Fast-Tracked Stage II expansion also includes a mining plan to deliver 0.85 Mtpa ore at average grade of 0.138% tin (Sn) to the upgraded materials handling and concentrating plant (MHCP), to produce 1 200 tpa of saleable tin concentrate for export. This is an increase in mining rate when compared to Phase 1 Stage I, where approximately 567 ktpa of pegmatite ore was delivered to the processing plant, to produce 788 tpa of saleable tin concentrate for export.

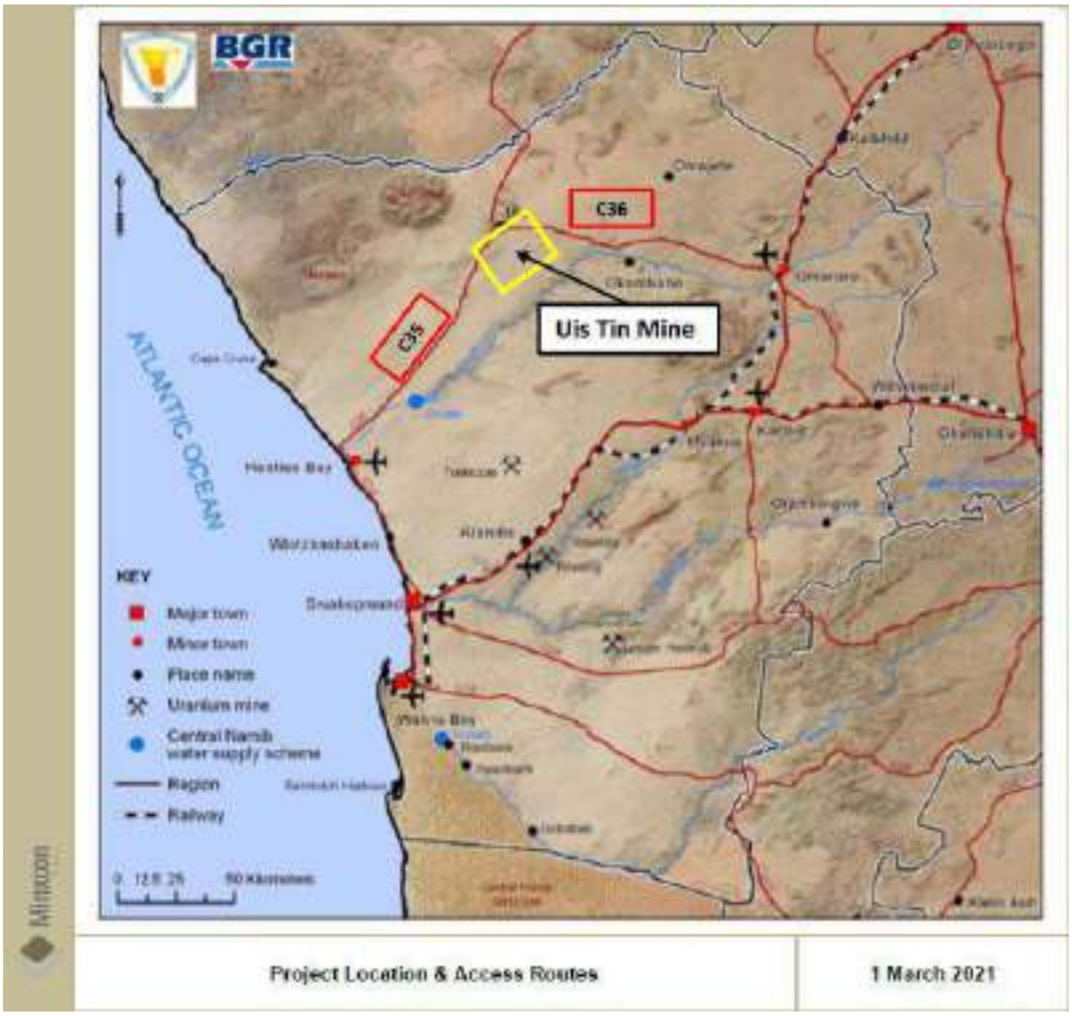

Figure 1: Regional location of the Uis Tin Mine Project

Subsequent to the above-mentioned changes to the mining and processing operations at Uis Tin Project, additional changes have to be made to the processing operations. Lithium and tantalum will be extracted in addition to tin, with a bulk sampling and ore sorting and testing facility to be constructed to extract the lithium-bearing ore. This will then be fed to a petalite beneficiation plant where the lithium will be extracted and processed. The waste from these two processes will be captured and handled in what they term a waste neutralisation facility. The DMS and flotation circuit will use hydrofluoric acid and sulphuric acid. Although the mining fleet will not change, there will be additional external traffic for the bulk sampling and testing campaigns.

1.1 Study Objective

The main objective of the investigation was to quantify the potential impacts resulting from the proposed activities on the surrounding environment and human health, and to recommend suitable management and mitigation measures.

1.2 Scope of Work

To meet the above objective, the following tasks were included in the initial Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the air quality legislative and regulatory context, including ambient air quality guidelines.
3. A study of the receiving (baseline) environment, including:
    a. The identification of air quality sensitive receptors (AQSRs) from available maps and field observations;
    b. A study of site-specific atmospheric dispersion potential by referring to available weather records, land use and topography data sources;
    c. The identification of existing sources of dust emissions at and around Uis;
    d. The characterisation of existing ambient air quality at and around Uis based on available ambient monitoring/modelling data (if available); and
    e. Analysis of dustfall monitoring data collected by Uis Tin Mine.
4. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Atmospheric dispersion simulations to determine ground level air concentrations (GLCs) and fallout levels as a result of the Project.
    c. The screening of GLCs and fallout levels against environmental air criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist air quality impact assessment report.

As part of the amendment to account for the bulk sampling and ore sorting and testing facility, the additional SoW include the following:

1. Quantify emissions associated with the bulk sampling and ore sorting and testing facility;
2. Rerun the dispersion model for the future scenario account for the updated proposed impacts form the mine and processing facility;
3. Assess potential for impacts from the mine and processing facility;
4. Provide recommendations and abatement options; and
5. Update the AQIA report to include the additional operations at the processing facility.

1.3 Project Description

The Project has a Life of Mine (LoM) of 18 years mining and 20 years processing to produce on average 1 200 tpa tin concentrate at a concentrate grade of 60%.

The activities that form part of normal operations at the Uis Tin Mine are:

- Opencast mining using the conventional truck and shovel mining method (including drilling and blasting of overburden and ore);
- Loading and hauling of waste from V2 open pit and V1 open pit to the designated waste rock dump and co-placement facility (CPF) respectively;
- Loading and hauling of ore to ROM stockpile at processing plant;

- Primary and secondary crushing and screening;
- Materials handling at crushed ore stockpile and DMS feed stockpile;
- Tertiary crushing and screening;
- Fines crushing and screening;
- Wet process:
    - DMS 1 circuit, followed by DMS 2 & 3;
    - Middlings and sinks re-crush;
    - Spiral plant;
    - Concentrate cleaning;
    - Water recovery and discard handling;
- Loading and hauling of discard to CPF;
- Bagging of concentrate into 1 tonne bulk bags; and
- Loading 26 dry metric tonne (DMT) batches onto flatbed truck for transport to Walvis Bay.

Air pollution associated with Project activities include air emissions emitted during the construction- and operational phases.

1.3.1 Description of Activities from an Air Quality Perspective

The construction phase during Stage II is designed to allow pre-assembly while the plant is in operation. Construction work packages include civil works, in-plant erection, piping, erection of conveyors and gantries, conveyor mechanical installation, and electrical, control and instrumentation work. Typical activities that would result in air pollution during the construction phase of Stage II are listed in Table 1.

Table 1: Construction activities resulting in air pollution

Activity	Associated pollutants
Construction Phase	
Handling and storage area for construction materials (paints, solvents, oils, grease) and waste	particulate matter (PM)[a] and fumes (Volatile Organic Compounds [VOCs])
Clearing and other earth moving activities	mostly PM, gaseous emissions from earth moving equipment (sulfur dioxide [SO_2]; oxides of nitrogen [NOx]; carbon monoxide [CO]; carbon dioxide [CO_2])
Foundation excavations	mostly PM, gaseous emissions from excavators (SO_2; NOx; CO; CO_2)
Delivery of materials – storage and handling of material such as sand, rock, cement, chemical additives, etc.	mostly PM, gaseous emissions from trucks (SO_2; NOx; CO; CO_2)
General building/construction activities including, amongst others: mixing of concrete; operation of construction vehicles and machinery; refuelling of machinery; civil, mechanical and electrical works; painting; grinding; welding; etc	mostly PM, gaseous emissions from construction vehicles and machinery (SO_2; NOx; CO; CO_2)

Notes: [a] Particulate matter (PM) comprises a mixture of organic and inorganic substances, ranging in size and shape and can be divided into coarse and fine particulate matter. Total Suspended Particulates (TSP) represents the coarse fraction >10µm, with particulate matter with an aerodynamic diameter of less than 10µm (PM_{10}) and particulate matter with an aerodynamic diameter of less than 2.5µm ($PM_{2.5}$) falling into the finer inhalable fraction. TSP is associated with dust fallout (nuisance dust) whereas PM_{10} and $PM_{2.5}$ are considered a health concern.

[b] CO_2 is a greenhouse gas (GHG).

Opencast mining and beneficiation plant activities most likely to result in air pollution during the operational phase are listed in Table 2. Activities associated with the additional bulk sampling and ore sorting and testing facility are also included in Table 2.

Table 2: Operational activities resulting in air pollution

Activity	Associated pollutants
Operational Phase	
Open pit mining: drilling and blasting	PM, SO_2; NOx; CO; CO_2
Open pit: excavation of ore and waste	mostly PM, gaseous emissions from mining equipment (PM, SO_2; NOx; CO; CO_2)
Haulage of materials (ore, waste and discard)	PM from road surfaces and windblown dust from trucks, gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2)
Co-placement facility (discard and waste)	PM from tipping, windblown dust, gaseous emissions from vehicle exhaust (PM, SO_2; NOx; CO; CO_2)
ROM and crushed ore stockpiles (ore)	PM from tipping and windblown dust
Conveyor transfers	PM from tipping and windblown dust
Processing of ore (crushing, screening, milling.)	mostly PM, gaseous emissions from machinery (PM, SO_2; NOx; CO; CO_2)
Transportation of product	PM from road surfaces, gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2)
Possible explosives magazine	gaseous emissions from open burning (PM, SO_2; NOx; CO; CO_2)
Bulk sampling and ore sorting and testing facility	PM from road surfaces due to haul trucks, tipping, crushing, drying and classification, storage of product and windblown dust

1.4 Approach and Methodology

The air quality study includes the assessment of both Baseline and proposed Project operations. The approach to, and methodology followed in the completion of tasks (or scope of work) are discussed below.

1.4.1 Project Information and Activity Review

An information requirements list was sent to ECC at the onset of the Project. In response to the request, the following information was supplied:

- Layout maps;
- Process descriptions; and
- Project equipment details.

Documentation reviewed included the following:

- Uis Tin Mine, Phase 1 Fast-Tracked Stage II Definitive Feasibility Study (AfriTin Mining, 2021).
- Air EnviroTech Dynamic Scrubber.pdf.
- Nexus-Ino Plant List & Power.
- AQ- MASTER ANALYSIS_20201019 new.xlsx.

1.4.2 The Identification of Regulatory Requirements and Health Thresholds

In the evaluation of ambient air quality impacts and dustfall rates reference was made to:

- National and international standards and guidelines, including but not limited to the World Health Organisation (WHO), US EPA, European Community, Namibia and South Africa.

1.4.3 Study of the Receiving Environment

Air quality sensitive receptors generally include private residences, community buildings such as schools, hospitals, and any publicly accessible areas outside an industrial facility's property.

As part of the air quality assessment, a good understanding of the regional climate and local dispersion potential of the site is necessary, as well as an understanding of existing sources of air pollution in the region and the current and potential future air quality. Physical environmental parameters that influence the dispersion of pollutants in the atmosphere include terrain, land cover and meteorology.

The Uis Mining Project does not have a weather station and use was made of Weather Research and Forecasting Model (WRF) modelled meteorological data for the Uis study area for the period 1 January 2018 – 31 December 2020, to (a) describe the dispersion potential of the site and (b) as input into the ADMS dispersion model.

1.4.4 Determining the Impact of the Project on the Receiving Environment

1.4.4.1 Emissions Inventory

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the Project's emissions on the receiving environment. In the quantification of emissions, use was made of emission factors which associate the quantity of release of a pollutant to the activity. Emissions were calculated using emission factors and equations published by the United States Environmental Protection Agency (US EPA) and Environment Australia (EA) in their National Pollutant Inventory (NPI) Emission Estimation Technique Manuals (EETMs).

To determine the significance of air pollution impacts from the Project, emissions were estimated for a Baseline scenario (based on Stage I throughputs) and a Project scenario (based on Stage II throughputs).

1.4.4.2 Air Dispersion modelling

The impact of proposed operations on the atmospheric environment was determined through the simulation of ambient pollutant concentrations. As per the National Code of Practice for Air Dispersion Modelling use was made of the internationally recognised ADMS 5 model (Atmospheric Dispersion Modelling System version 5.0.0) developed by the Cambridge Environmental Research Consultants (CERC) for the simulation of ambient air pollutant concentrations and dustfall rates.

The dispersion model uses the specific input data to run various algorithms to estimate the dispersion of pollutants between the source and receptor. The model output is in the form of a simulated time-averaged concentration at the receptor. These simulated concentrations are compared with the relevant ambient air quality standard or guideline. Ambient air quality guidelines and standards are applicable to areas where the general public has access i.e. off-site.

1.4.5 Compliance Assessment

The legislative and regulatory context, including emission limits and guidelines, ambient air quality guidelines and dustfall classifications were used to assess the impact and recommend additional emission controls, mitigation measures and air quality management plans to maintain the impact of air pollution to acceptable limits in the study area. The model results were analysed against the Air Quality Objectives recommended as part of the Strategic Environmental Management Plan (SEMP) Air Quality Management Plan (AQMP) (Liebenberg-Enslin, et al., 2019). These objectives are based on the WHO interim targets and SA National Air Quality Standards and dustfall criteria.

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1.4.6 Impact Significance

Potential impacts of the proposed Project were identified based on the baseline data, project description, review of other studies for similar projects and professional experience. The significance of air quality impacts was assessed according to the methodology provided by ECC, considering both an unmitigated and mitigated scenario. Refer to Appendix C of this report for the methodology. The impact significance was rated for unmitigated operations and assuming the effective implementation of design mitigation measures.

1.4.7 The Development of an Air Quality Management Plan

The findings of the above components informed recommendations of air quality management measures, including mitigation and monitoring.

1.5 ESIA Amendment

The ESIA for the Uis Tin Mine is to be amended to include material changes they intend on adding to their existing operations. A bulk sampling and ore sorting and testing facility will be constructed to extract the lithium-bearing ore. This will then be fed to a petalite beneficiation plant where the lithium will be extracted and processed. The waste from these two processes will be captured and handled in what the mine terms a waste neutralisation facility.

The neutralised discard will undergo a kinetic leach testing campaign before disposal. This will determine the success of the neutralisation process. Until results are obtained from the leach testing campaign, the filter cake discard material will be stored in either a concreted bunded area or directly deposited into Rent-A-Drum skips which will be disposed of at the Walvis Bay Hazardous Waste Disposal Facility. Once the results from the leach testing campaign is received, the mine will then plan waste disposal accordingly.

The reagents that will be used in the wet section of the plant (DMS and flotation circuit) are hydrofluoric acid and sulphuric acid in 5 tonnes and 3 tonnes respectively each per month per the 2000 tonnes sampling campaign. The engineering design for this plant is underway and schematics of its design will be included in the ESIA report with an assessment of the potential impacts associated with such a facility.

1.5.1 Determining the Impact of the Project on the Receiving Environment

An emission inventory was set up for the ESIA Amendment based on the information that was received, which included:

2108600 Afritin Uis Platforms Layout_Rev0_2022-08-08.dwg
Petalite Plant_Hazardous discard calc.xlsx
Project descriptions via email.

To determine the significance of air pollution impacts from the Project, emissions were estimated for an incremental Project scenario (based on approximate throughputs for the proposed petalite beneficiation plant) and a cumulative Project scenario (taking into account the ESIA Amendment operations and Project operations as described in Section 1.3).

The impact of proposed operations on the atmospheric environment was determined through the simulation of ambient pollutant concentrations using the ADMS model. An assessment was made whether cumulative Project impacts differ significantly from Project impacts (assessed in Section 1.4.4).

1.6 Assumptions, Exclusions and Limitations

The main assumptions, exclusions and limitations are summarized below:

- Meteorological data: WRF modelled meteorological data for the site over the period January 2018 – December 2020 was used.
- Emissions (mining):
  - The quantification of sources of emission was restricted to the Uis Tin Mine activities only. Although other background sources were identified, such sources were not quantified and modelled.
  - Information required for the calculation of emissions from fugitive dust sources for the mining operations was provided. The assumption was made that this information was accurate and correct.
  - Only routine emissions were estimated and modelled. This was done for the provided operational hours.
  - Working hours were provided as 24-hour days, 7 days a week for open-pit mining activities. Total operating hours per annum were provided for different sections of the plant. For ease of modelling and to present a worst-case scenario, however, it was assumed that the plant operated continuously. Blasting was assumed to occur 2 times a week for waste and once a week for ore.
  - Vehicle exhaust emissions were not quantified as the impacts from these sources are localized and unlikely to exceed health screening limits offsite.
  - Particle size distribution for waste, ROM and co-disposal material was based on information from similar mining processes.
  - It was assumed that Stage I throughputs as provided in the DFS summary represent the Baseline scenario (current mining rates) and that Stage II throughputs represent the Project scenario (future mining rates).
  - It was assumed that the flow of materials stays the same proportionally for the Baseline and Project scenarios, apart from the additional (i) crushing and screening stage to enable increased throughput and (ii) buffer stockpile between the crushing and beneficiation sections, for the Project scenario.
  - In the absence of detailed construction plans, emissions were quantified using an area-wide emission factor (for approximate areas earmarked for construction).
- Emissions (ESIA amendment):
  - The quantification of sources of emission was restricted to activities for which data and georeferenced locations were available.
  - Working hours were advised as daytime for crushing activities and continuously for DMS operation.
  - No construction data was available, and construction emissions were therefore not estimated.
- Impact assessment:
  - Impacts due to the construction phase of the Project were assessed qualitatively due to the temporary nature of these operations, whilst the operational phase was assessed quantitatively.

1.7 Outline of Report

The regulatory requirements and assessment criteria are discussed in Section 2. The basic site description and identification of possible environmental aspects are discussed in Section 3. This is followed by the impact assessment, comprising of an emission inventory, atmospheric dispersion modelling and inhalation health risk screening in Section 4. An assessment of the incremental and cumulative impacts due to the proposed testing facility is provided in Section 5. Recommendations of air quality management measures, including mitigation and monitoring are provided in Section 6.

2 LEGAL OVERVIEW

Prior to assessing the potential impacts from the proposed mine on the surrounding environment and human health, reference needs to be made to the environmental regulations and guidelines governing the emissions and impact of such activities. Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. Air quality guidelines and standards are based on benchmark concentrations that normally indicate safe daily exposure levels for the majority of the population including the very young and the elderly, throughout an individual's lifetime. Benchmark concentrations could therefore be based on health effects, such as SO_2 or carcinogenic consequences, such as benzene.

Air quality guidelines and standards are normally given for specific averaging or exposure periods and are evaluated as the observed air concentration expressed as a fraction of a benchmark concentration. A standard, as opposed to a benchmark concentration only, is a set of instructions which include a limit value and may contain a set of conditions to meet this limit value. Standards are normally associated with a legal requirement as implemented by the country's relevant authority; however, organizations such as the World Bank Group (WBG), International Finance Corporation and private companies also issue standards for internal compliance. The benchmark concentrations issued by the World Health Organization (WHO) on the other hand, are not standards, but rather guidelines that may be considered for use as limit values in standards.

A common condition included in a standard is the allowable frequency of exceedances of the limit value. The frequency of exceedances recognises the potential for unexpected meteorological conditions coupled with emission variations that may result in outlier air concentrations and would normally be based on a percentile, typically the 99^{th} percentile.

Standards are normally issued for criteria pollutants, i.e. those most commonly emitted by the industry including SO_2, NO_2, CO, PM_{10} and $PM_{2.5}$, but may also include secondary pollutants such as ozone (O_3). Some countries include other pollutants, specifically when these are considered problematic emissions.

In addition to ambient air quality standards or guidelines, emission limits aim to control the amount of pollution from a point source[2]. Emissions to air should be avoided or controlled according to Good International Industry Practice (GIIP) applicable to the specific industry sector (IFC, 2007a).

Namibia does not have air quality guidelines or limits and reference is usually made to international ambient air quality guidelines and standards. The WHO is widely referenced, including regional neighbours such as South Africa and Botswana who have air quality standards. As part of the AQMP developed for the SEMP update, ambient guidelines for PM_{10} and $PM_{2.5}$ were determined to provide the necessary performance indicators for mines and industries within the Erongo Region. These guidelines are regarded applicable to the current study and discussed in the following sub-sections.

2.1 Namibian Legislation

The Atmospheric Pollution Prevention Ordinance (No. 11 of 1976) deals with the following:

Part I	:	Appointment and powers of officers;
Part II	:	Control of noxious or offensive gases;
Part III	:	Atmospheric pollution by smoke;
Part IV	:	Dust control;
Part V	:	Pollution of the atmosphere by gases emitted by vehicles;
Part VI	:	General provisions; and

[2] Point sources are discrete, stationary, identifiable sources of emissions that release pollutants to the atmosphere (IFC, 2007).

Schedule 2: Scheduled processes.

The Ordinance does not include any ambient air standards with which to comply, but opacity guidelines for smoke are provided under Part III. It is implied that the Director[3] provides air quality guidelines for consideration during the issuing of Registration Certificates, where Registration Certificates may be issued for "Scheduled Processes" which are processes resulting in noxious or offensive gases and typically pertain to point source emissions. To our knowledge no Registration Certificates have been issued in Namibia. However, an Environmental Clearance Certificate is required for any activity entailing a scheduled process as referred to in the Atmospheric Pollution Prevention Ordinance, 1976.

Also, the Ordinance defines a range of pollutants as noxious and offensive gases, but no ambient air quality guidelines or standards or emission limits are provided for Namibia.

Part II of the Ordinance pertains to the regulation of noxious or offensive gases. The Executive Committee may declare any area a *controlled area* for the purpose of this Ordinance by notice in the Official Gazette. Any scheduled process carried out in a *controlled area* must have a current registration certificate authorising that person to carry on that process in or on those premises.

The published Public and Environmental Health Act 1 of 2015 provides "a framework for a structured uniform public and environmental health system in Namibia; and to provide for incidental matters". The act identifies health nuisances, such as chimneys sending out smoke in quantities that can be offensive, injurious or dangerous to health and liable to be dealt with.

2.1.1 Best Practice Guide for the Mining Sector in Namibia

A Best Practice Guide for the Mining Sector in Namibia was published in November 2019 (NCE, 2019). The document serves as a guiding framework during all mining phases to effectively assess aspects such as environmental and social impacts.

The report lists air quality as an environmental risk. It provides examples of sources and activities that would result in particulate and gaseous emissions and gives guidance on management and control of these source activities. Aspects relevant to the Uis Mining Project can be summarised as follows:

- The benefits of the SEMP for industry are highlighted and the SEMP Environmental Quality Objectives (EQOs) require as a minimum management objective that "any change to the environment must be within acceptable limits, and that proactive intervention will be triggered by the responsible party to avoid unwanted changes that breach a specific threshold." All mining companies within the region submit reports annually as part of the SEMP annual report which is available in the public domain.
- Section 3 provides requirements for Baseline Studies where air quality is listed as one of the most important aspects where background conditions of dust, gaseous and nuisance emissions and in some cases fumes and odours are required. Dust and gaseous emissions require immediate monitoring, as well as the establishment of a network of meteorological measuring points. Dust requires the monitoring of particulate matter (PM), in PM_{10}–format, but the monitoring program may require simultaneous measurement of TSP or $PM_{2.5}$ as well.
- Applicable ambient air quality guidelines are listed in Section 3 of the report. It states that Namibia does not have ambient air quality standards or guidelines and references the SEMP AQMP (Liebenberg-Enslin, et al., 2019)

[3] *Director* means the Director of Health Services of the Administration, and, where applicable, includes any person who, in terms of any authority is granted to him under section 2(2) or (3) of the Ordinance.

guidelines which were determined to provide the necessary performance indicators for the region. These are discussed in more detail under Section 2.4.

- Recommendations in Section 3 include: Dust Management Plans for all operational sites (mines, exploration sites and quarries); annual reporting of dust fall levels and PM_{10} concentrations to the authorities; dust suppression at construction sites (as well as annual reporting on dust mitigation measures); update and improvement of the current emissions inventory; establishing a monitoring regime to enhance source apportionment of PM concentrations and sodium content; and continuation with PM_{10} and meteorological monitoring.
- Section 4 indicates that once mines are operational, an air quality management plan is essential for dealing with issues that can potentially have an adverse impact on operations. In addition to dust, an air quality plan needs to incorporate the management of emissions (release of pollutants and particulates) and fumes as well. All mines must, as a minimum requirement of an air quality management plan, manage dust.
- Requirements for air quality monitoring during the operational phase is provided under Section 6.2.3 of the Guide and reference is made again to the SEMP guidelines as performance indicators for the region. All the uranium mines in Namibia are located in the Erongo Region and all these mines have extensive air quality monitoring programmes in place.
- Section 5 provides guidance on closure and maintenance where management and monitoring of erosion is one of the essential aspects.

2.2 International Criteria

Typically, when no local ambient air quality criteria exist, or are in the process of being developed, international criteria are referenced. This serves to provide an indication of the severity of the potential impacts from proposed activities. The most widely referenced international air quality criteria are those published by the WBG, the WHO, and the European Community (EC). The South African (SA) National Ambient Air Quality Standards (NAAQS) are also referenced since it is regarded representative indicators for Namibia due to the similar environmental and socio-economic characteristics between the two countries. The PM guidelines selected as part of the SEMP AQMP for the Erongo Region were based on these international guidelines and standards, and the following subsections provide the relevant background.

2.2.1 WHO Air Quality Guidelines

Air Quality Guidelines (AQGs) were published by the WHO in 1987 and revised in 1997. Since the completion of the second edition of the AQGs for Europe, which included new research from low-and middle-income countries where air pollution levels are at their highest, the WHO has undertaken to review the accumulated scientific evidence and to consider its implications for its AQGs. The result of this work is documented in *'Air Quality Guidelines – Global Update 2005'* in the form of revised guideline values for selected criteria air pollutants, which are applicable across all WHO regions (WHO, 2005).

Since WHO's last 2005 global update, there has been a marked increase of evidence that shows how air pollution affects different aspects of health. For that reason, and after a systematic review of the accumulated evidence, WHO has adjusted almost all the AQGs levels downwards, warning that exceeding the new air quality guideline levels is associated with significant risks to health (WHO, 2021). Across nearly all pollutants, the new recommended limits for concentrations and exposures are lower than the previous guidelines. The 2021 update reflects far-reaching evidence that shows how air pollution affects many aspects of health, even at low levels.

Given that air pollution levels in developing countries frequently far exceed the recommended WHO AQGs, interim target (IT) levels were included in the update. These are in excess of the WHO AQGs themselves, to promote steady progress towards meeting the WHO AQGs (WHO, 2005). There are two or three interim targets depending on the pollutant, starting at WHO interim target-1 (IT-1) as the most lenient and IT-2 or IT-3 as more stringent targets before reaching the AQGs. The SA NAAQS are, for instance, in line with IT-1 for SO_2 and IT-3 targets for PM_{10} and $PM_{2.5}$. It should be noted that the WHO permits a frequency of exceedance of 1% per year (4 days per year) for 24-hour average PM_{10} and $PM_{2.5}$ concentrations. In the absence of interim targets for NO_2, reference is made to the AQG value. These are provided in Table 3 for pollutants considered in this study.

2.2.2 SA National Ambient Air Quality Standards

NAAQSs for SA were determined based on international best practice for SO_2, NO_2, $PM_{2.5}$, PM_{10}, O_3, CO, lead (Pb) and benzene. These standards were published in the Government Gazette on 24 of December 2009 and included a margin of tolerance (i.e. frequency of exceedance) and with implementation timelines linked to it. SA NAAQSs for $PM_{2.5}$ were published on 29 July 2012. As mentioned previously, SA NAAQS closely follow WHO interim targets, which are targets for developing countries, for $PM_{2.5}$, PM_{10} and SO_2. The SA NAAQS for ambient NO_2 concentrations is equivalent to the WHO AQG. SA NAAQSs referred to in this study are also given in Table 3.

Table 3: International assessment criteria for criteria pollutants

Pollutant	Averaging Period	WHO Guideline Value (µg/m³)	South Africa NAAQS (µg/m³)
Sulfur Dioxide (SO_2)	1-year 24-hour 1-hour 10-minute	- 125 (IT1) 50 (IT2) (a) 40 (guideline) - 500 (guideline)	50 125 (b) 350 (c) 500 (d)
Nitrogen Dioxide (NO_2)	1-year 24-hour 1-hour	40 (IT1) 30 (IT2) 20 (IT3) 10 (guideline) 120 (IT1) 50 (IT2) 25 (guideline) 200 (guideline)	40 200 (c)
Particulate Matter (PM_{10})	1-year 24-hour	70 (IT1) 50 (IT2) 30 (IT3) 20 (IT4) 15 (guideline) 150 (IT1) 100 (IT2) 75 (IT3) 50 (IT4) 45 (guideline)	40 (e) 75 (e) (b)
Particulate Matter ($PM_{2.5}$)	1-year	35 (IT1) 25 (IT2) 15 (IT3)	25 (f) 20 (g) 15 (h)

Pollutant	Averaging Period	WHO Guideline Value (µg/m³)	South Africa NAAQS (µg/m³)
		10 (IT4) 5 (guideline)	
	24-hour	75 (IT1) 50 (IT2) 37.5 (IT3) 25 (IT4) 15 (guideline)	65 (f) 40 (g) 25 (h)

Notes:

(a) Intermediate goal based on controlling motor vehicle emissions, industrial emissions and/or emissions from power production. This would be a reasonable and feasible goal to be achieved within a few years for some developing countries and lead to significant health improvement.
(b) 4 permissible frequencies of exceedance per year
(c) 88 permissible frequencies of exceedance per year
(d) 526 permissible frequencies of exceedance per year
(e) Applicable from 1 January 2015
(f) 4 permissible frequencies of exceedance per year
(g) Applicable immediately to 31 December 2015
(h) Applicable 1 January 2016 to 31 December 2029
(i) Applicable 1 January 2030

2.2.3 Dustfall Rates

Air quality standards are not defined by all countries for dust deposition, although some countries may make reference to annual average dustfall thresholds above which a 'loss of amenity' may occur. In the Southern African context, widespread dust deposition impacts occur as a result of windblown dust from natural sources, mining operations, waste rock dumps, stockpiles, tailings and other fugitive dust sources.

South Africa published the National Dust Control Regulations (NDCR) on the 1st of November 2013 (Government Gazette No. 36974). The purpose of the regulations is to prescribe general measures for the control of dust in all areas including residential and light commercial areas. Similarly, Botswana published dust deposition evaluation criteria (BOS 498:2013). According to these limits, an enterprise may submit a request to the authorities to operate within the Band 3 (action band) for a limited period, providing that this is essential in terms of the practical operation of the enterprise (for example the final removal of a tailings deposit) and provided that the best available control technology is applied for the duration. No margin of tolerance will be granted for operations that result in dustfall rates in the Band 4 (alert band). The four-band scale published by the Botswana Bureau of Standards is presented in Table 4.

.

Table 4: Bands of dustfall rates

Band Number	Band Description Label	30 Day Average Dustfall Rate (mg/m^2-day)	Comment
1	RESIDENTIAL	D < 600	Permissible for residential and light commercial
2	INDUSTRIAL	600 < D < 1 200	Permissible for heavy commercial and industrial
3	ACTION	1 200 < D < 2 400	Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year.
4	ALERT	2 400 < D	Immediate action and remediation required following the first exceedance. Incident report to be submitted to relevant authority.

Source: BOS 498:2013

2.3 International Conventions

The technical reference documents published in the IFC Environmental, Health and Safety (EHS) Guidelines provide general and industry specific examples of Good International Industry Practice (GIIP). The General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines (IFC, 2007).

The IFC EHS Guidelines provide a general approach to air quality management for a facility, including the following:

- Identifying possible risks and hazards associated with the Project as early on as possible and understanding the magnitude of the risks, based on:
    - the nature of the Project activities; and,
    - the potential consequences to workers, communities, or the environment if these hazards are not adequately managed or controlled.
- Preparing Project- or activity-specific plans and procedures incorporating technical recommendations relevant to the Project or facility;
- Prioritising the risk management strategies with the objective of achieving an overall reduction of risk to human health and the environment, focusing on the prevention of irreversible and / or significant impacts;
- When impact avoidance is not feasible, implementing engineering and management controls to reduce or minimise the possibility and magnitude of undesired consequence; and,
- Continuously improving performance through a combination of ongoing monitoring of facility performance and effective accountability.

Significant impacts to air quality should be prevented or minimised by ensuring that:

- Emissions to air do not result in pollutant concentrations exceeding the relevant ambient air quality guidelines or standards. These guidelines or standards can be national guidelines or standards or in their absence WHO AQGs or any other international recognised sources.
- Emissions do not contribute significantly to the relevant ambient air quality guidelines or standards. It is recommended that 25% of the applicable air quality standards are allowed to enable future development in a given airshed. Thus, any new development should not result in ground level concentrations exceeding 25% of the guideline value.
- The EHS recognises the use of dispersion models to assess potential ground level concentrations. The models used should be internationally recognised or comparable.

2.3.1 Degraded Airsheds or Ecological Sensitive Areas

The IFC provides further guidance on projects located in degraded airsheds (IFC, 2007), i.e. areas where the national/ WHO/ other recognised international Air Quality Guidelines are significantly exceeded or where the project is located next to areas regarded as ecological sensitive such as national parks. The Uis Tin Mine Project is not located in an ecologically sensitive area, and the airshed is not regarded to be degraded.

2.3.2 Fugitive Source Emissions

According to the IFC (IFC, 2007), fugitive source emissions refer to emissions that are distributed spatially over a wide area and confined to a specific discharge point. These sources have the potential to result in more significant ground level impacts per unit release than point sources. It is therefore necessary to assess this through ambient quality assessment and monitoring practices.

2.4 Recommended Guidelines and Objectives

The IFC references the WHO guidelines but indicates that any other internationally recognized criteria can be used such as the United States (US) Environmental Protection Agency (EPA) or the EC. It was however found that merely adopting the WHO guidelines would result in potential non-compliance in many areas due to the arid environment in the country, and specifically in Namibia. The WHO states that these AQG and interim targets should be used to guide standard-setting processes and should aim to achieve the lowest concentrations possible in the context of local constraints, capabilities, and public health priorities. These guidelines are also aimed at urban environments within developed countries (WHO, 2005). For this reason, the South African NAAQS are also referenced since these were developed after a thorough review of all international criteria and selected based on the socio, economic and ecological conditions of the country.

In the absence of guidelines on particulate concentrations for Namibia, reference is made to the Air Quality Objectives (AQO) recommended as part of the SEMP AQMP (Liebenberg-Enslin, et al., 2019). These objectives are based on the World Health Organisation (WHO) interim targets and SA NAAQS (Table 3). The criteria were selected on the following basis:

- The WHO IT3 was selected for particulates since these limits are in line with the South African NAAQSs, and the latter is regarded feasible limits for the arid environment of Namibia.
- Even though $PM_{2.5}$ emissions are mainly associated with combustion sources and mainly a concern in urban environments, it is regarded good practice to include as health screening criteria given the acute adverse health effects associated with this fine fraction. Also, studies found that desert dust with an aerodynamic diameter 2.5 µm cause premature mortality.
- The Botswana and South African criteria for dust fallout are the same and with limited international criteria for dust fallout, these were regarded applicable.

The proposed AQOs as set out in Table 5 are used as indicators during the impact assessment.

Table 5: Proposed evaluation criteria for Namibia

Pollutant	Averaging Period	Selected Criteria	Origin
$PM_{2.5}$	24-hour Mean (µg/m³)	37.5 (a)	WHO IT3 (as per SEMP AQMP)
	Annual Mean (µg/m³)	15	WHO IT3 & SA NAAQS (as per SEMP AQMP)
PM_{10}	24-hour Mean (µg/m³)	75 (a)	WHO IT3 & SA NAAQS (as per SEMP AQMP)
	Annual Mean (µg/m³)	40	SA NAAQS (as per SEMP AQMP)
Dustfall	30-day average (mg/m²/day)	600 (b)	SA NDCR & Botswana residential limit
		1200 (b)	SA NDCR & Botswana industrial limit
		2400 (c)	Botswana Alert Threshold

Notes:

(a) Not to be exceeded more than 4 times per year (SA).

(b) Not to be exceeded more than 3 times per year or 2 consecutive months.

(c) First exceedance requires remediation and compulsory report to authorities

3 DESCRIPTION OF THE RECEIVING/BASELINE ENVIRONMENT

3.1 Site Description

The Uis Tin Mining Project is located near the settlement of Uis, which is situated in Damaraland (viz. the rural areas of the Erongo region, Namibia). The small Uis mining village which was developed to support the historical mine lies adjacent to the northeast of the Project. Access to the Project is obtained via an established road network that connects the Project to larger towns and cities with modern infrastructure. The two main access routes to the Project are via the C36 from the town of Omaruru and the C35 from the town of Henties Bay.

The Uis mining area and plant layout, as well as air quality sensitive receptors are shown in Figure 2. The receptor locations were identified from Google Earth and Google Maps satellite imagery. Uis town and Uis mining village lie ~1.9 km northwest and 1.7 km northeast of the mining area respectively, with the informal settlement Tatamutsi situated ~3.4 km northeast.

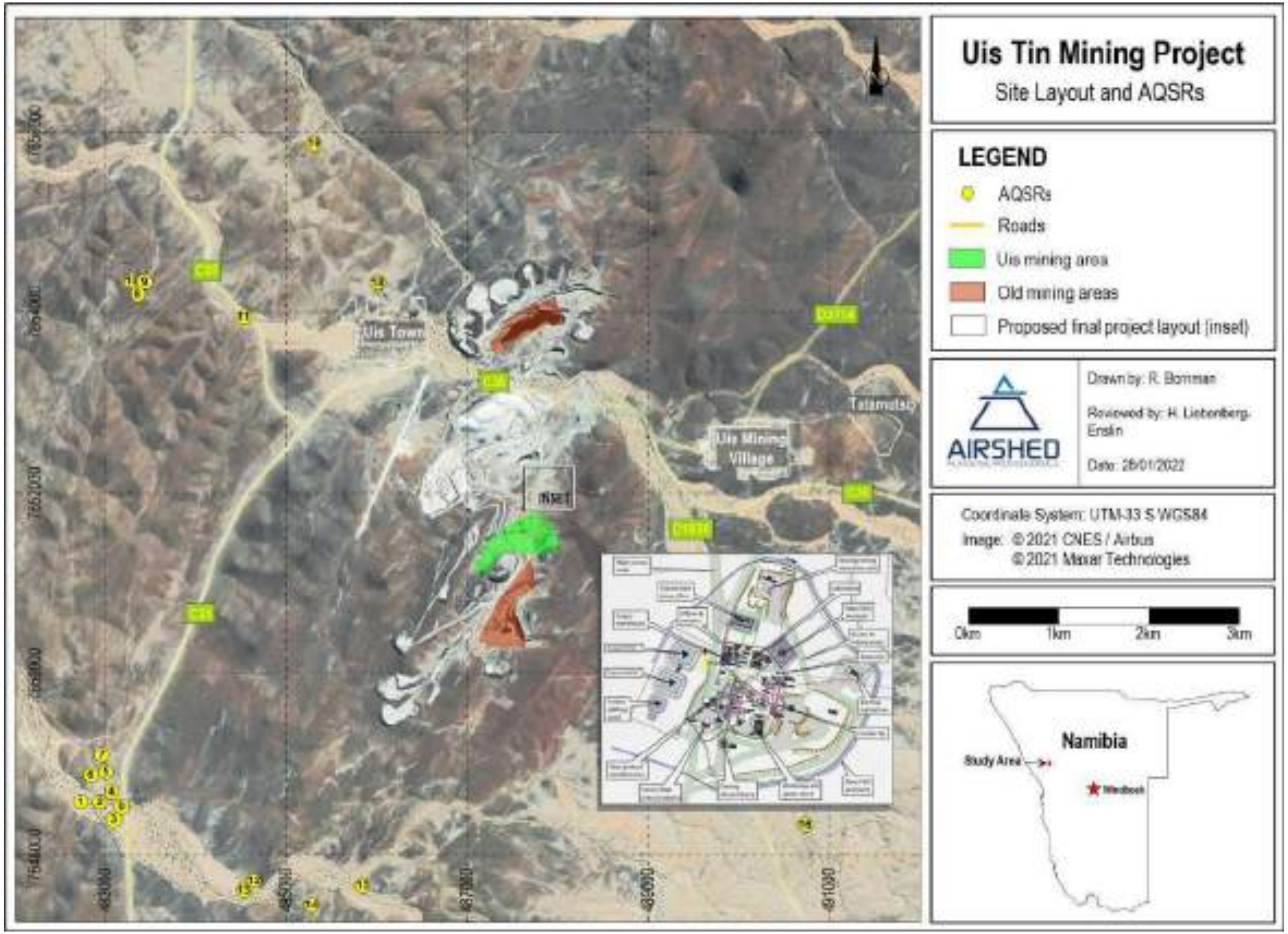

Figure 2: Site layout and air quality sensitive receptors (AQSRs)

3.2 Atmospheric Dispersion Potential

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field.

A description of the wind field, temperature, precipitation, and atmospheric stability is provided in the following section.

3.2.1 Surface Wind Field

The wind direction, and the variability in wind direction, determines the general path air pollutants will follow, and the extent of crosswind spreading.

Wind roses comprise 16 spokes, which represent the directions from which winds blew during the period. The colours used in the wind roses below, reflect the different categories of wind speeds; the red area, for example, representing winds higher than 10 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred refers to periods during which the wind speed was below 1 m/s.

Reference was made to WRF modelled meteorological data for the Uis study area for the period 1 January 2018 to 31 December 2020. Period, daytime and night-time wind roses for the study area are depicted in Figure 3.

The wind field in the area is dominated by winds from the southwest during the day and night, with an increase in winds from the south-southwest and south during the night. Day- and night-time average wind speeds are 4.6 m/s and 5.0 m/s respectively. Calm conditions occur 3.0% of time during the day and 2.5% during the night. On average, air quality impacts are expected to be slightly more notable to the north and north-east of the Project.

The seasonal variability in the wind field is shown in Figure 4. The highest wind speeds (more than 6 m/s) occur during summer and springtime and are mostly from the south-southwest and southwest (Figure 4).

The predominant south-south-westerly, southerly and north-north-easterly winds in the study region may be explained by the topography of the study area. Uis is located approximately 30 km northwest of the Brandberg mountain, Namibia's highest mountain (2 559 m above sea level). Uis is ~800 m above sea level with the highest point at 900 m above sea level, as can be seen in Figure 5. The immediate mine surroundings are relatively flat, with steeper and higher relief areas confined to the northeast and south.

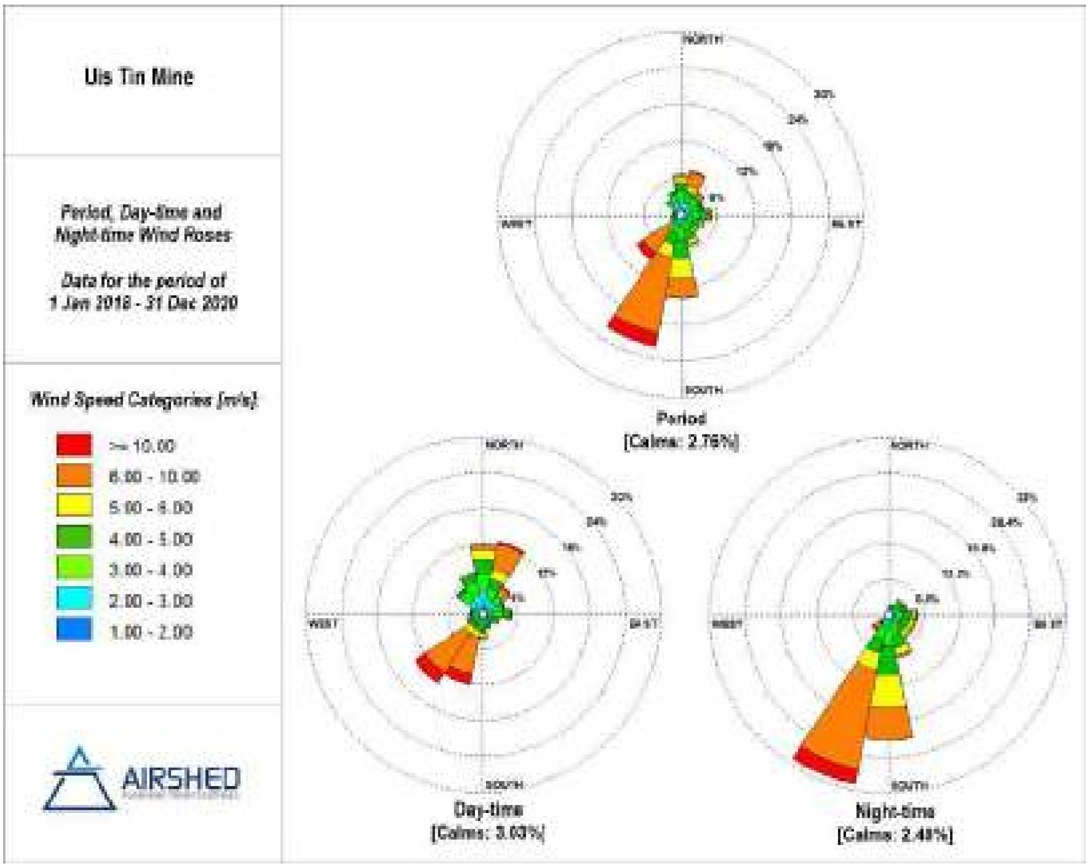

Figure 3: Period, day- and night-time wind roses based on modelled WRF data for Uis Mine (Jan 2018 – Dec 2020)

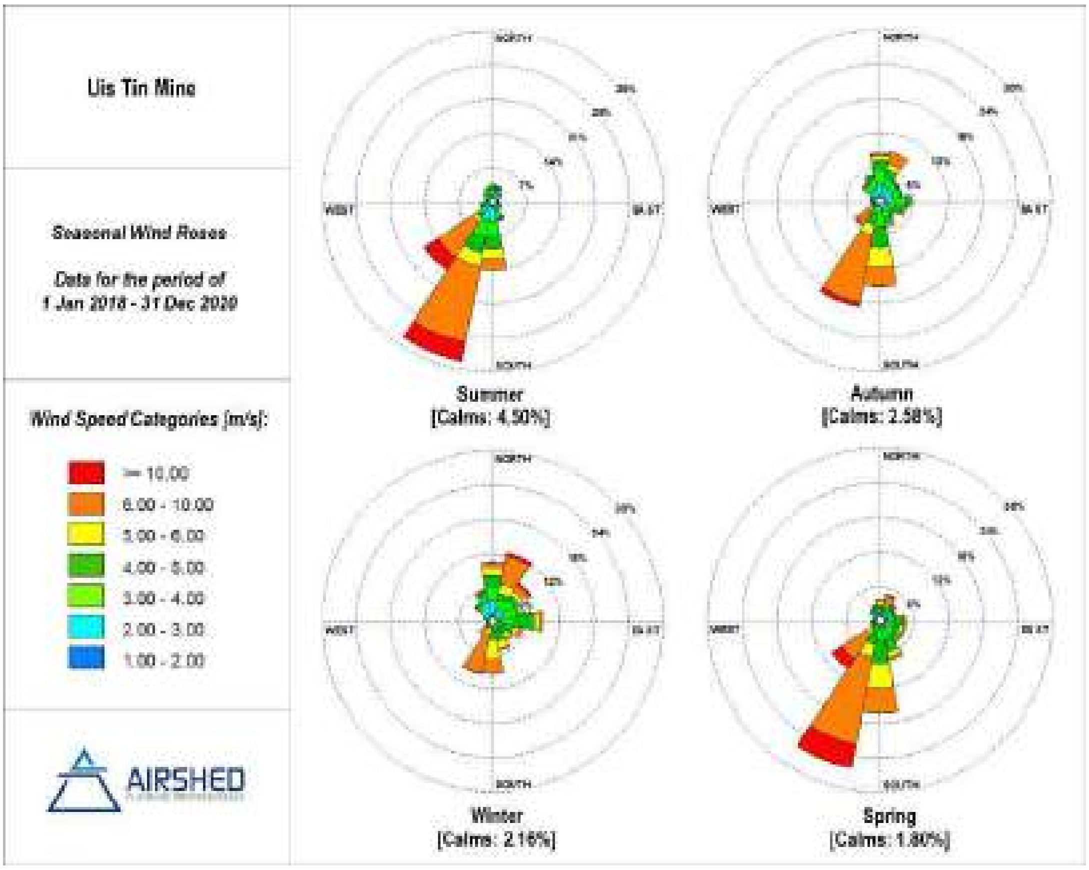

Figure 4: Seasonal wind roses based on modelled MM5 data for Uis Mine (Jan 2018 – Dec 2020)

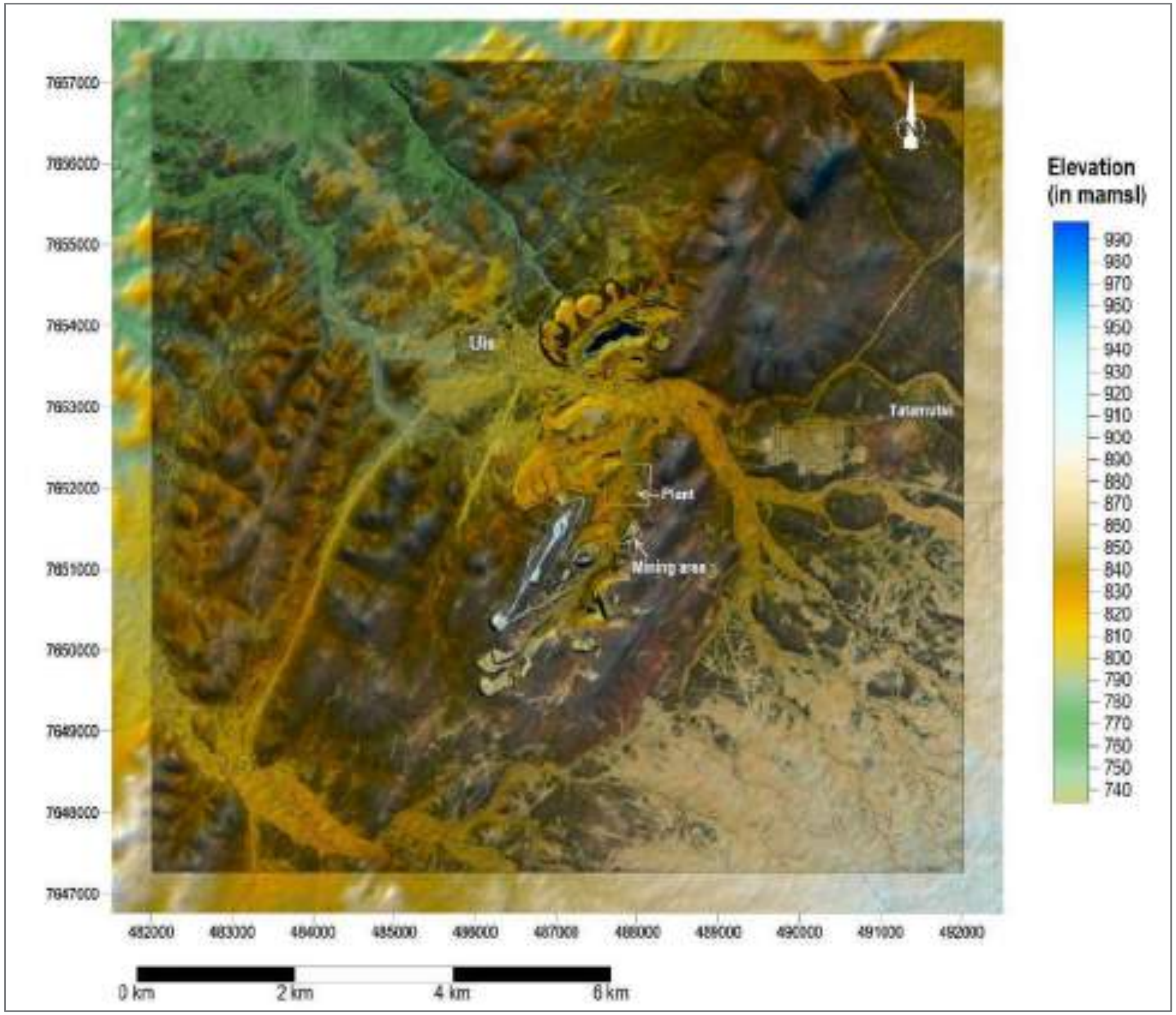

Figure 5: Topography of the study region

3.2.2 Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume can rise), and determining the development of the mixing and inversion layers.

Maximum, minimum and mean temperatures for the study area are given as 39.9°C, 1.2°C and 22.5°C respectively, based on modelled WRF data for the period 2018-2020. Maximum temperatures range from 39.9°C in November to 32.6°C in June, with minima ranging from 14.6°C in April to 1.2°C in August (Figure 6).

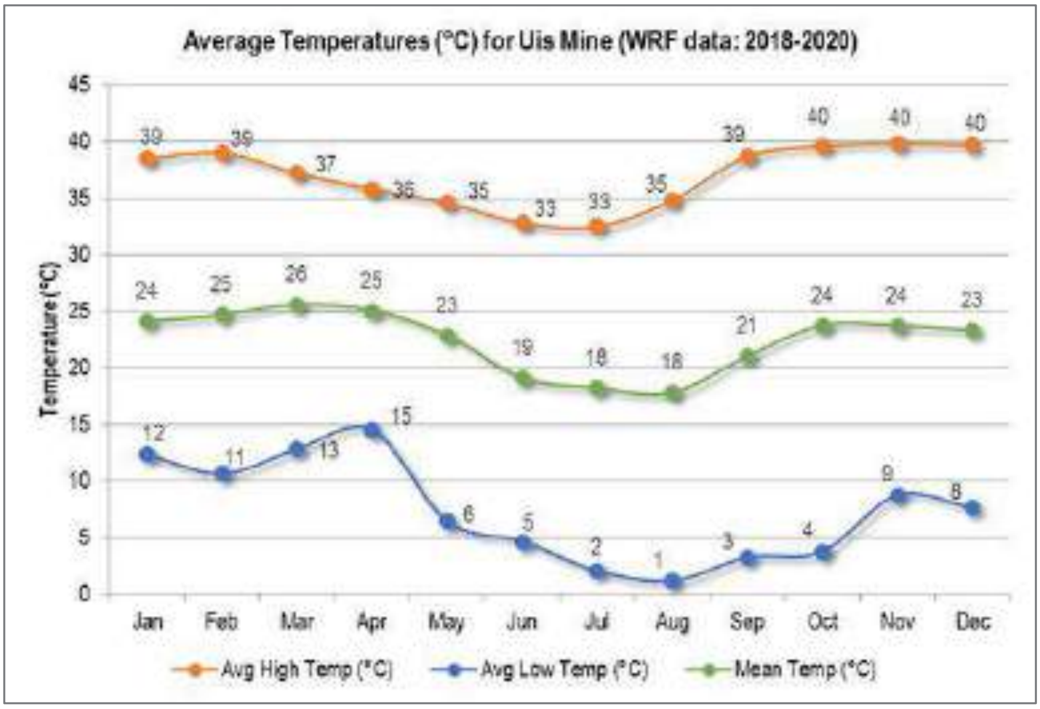

Figure 6: Average temperatures for Uis Mine (WRF data, 2018 – 2020)

Diurnal temperature trends are presented in Figure 7. During the day, temperatures increase to reach maximum at around 12:00 in the afternoon. Ambient air temperatures decrease to reach a minimum at around 06:00 i.e. just before sunrise. The average day-time temperature is given as 26.3°C, whereas the average night-time temperature is given as 18.6°C.

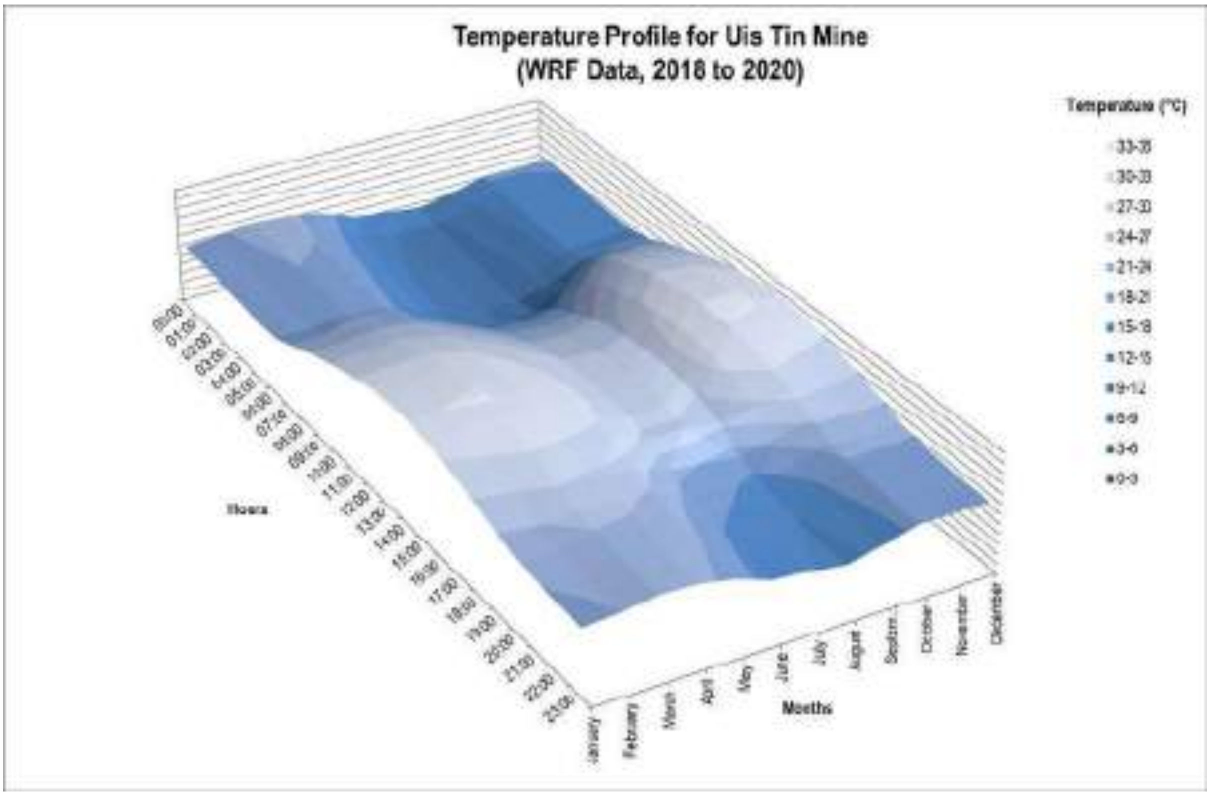

Figure 7: Diurnal temperature profile for Uis Mine (WRF data, 2018 – 2020)

3.2.3 Precipitation

Precipitation is important to air pollution studies since it represents an effective removal mechanism for atmospheric pollutants and inhibits dust generation potentials. Long-term monthly average rainfall figures obtained from worldweatheronline.com are illustrated in Figure 8.

On average, the area receives approximately 656 mm of rain per year, with 86 rainy days per year. There is a rainy season from December through March and a dry season from May to September, with February being the wettest month and July the driest.

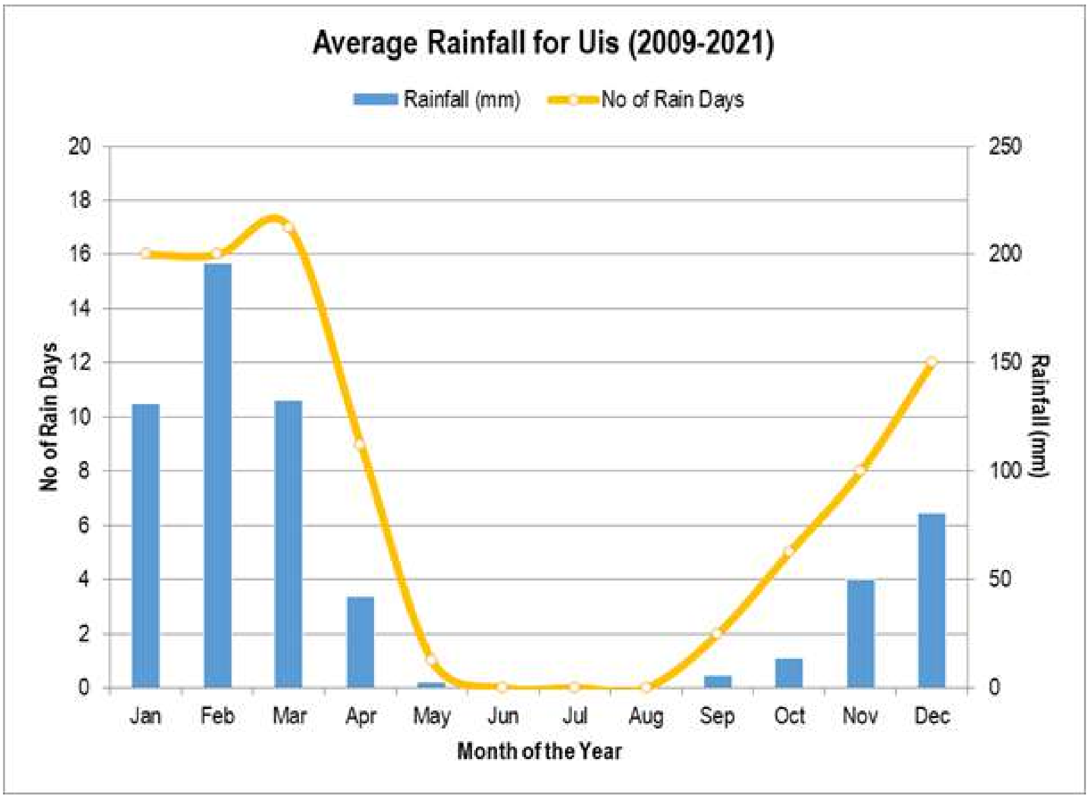

Figure 8: Long-term average rainfall for Uis, Namibia (worldweatheronline.com)

3.2.4 Atmospheric Stability

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class. The Monin-Obukhov length (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

Diurnal variation in atmospheric stability described by the inverse Monin-Obukhov length and the mixing height is provided in Figure 9.

The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions. For elevated releases, such as a stack, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called *looping* and occurs mostly during daytime hours (Figure 9(c)). Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as *coning* (Figure 9(b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Figure 9(a)) (Tiwary & Colls, 2010). For ground level releases, such as fugitive dust from mining activities, the highest ground level concentrations will occur during stable night-time conditions.

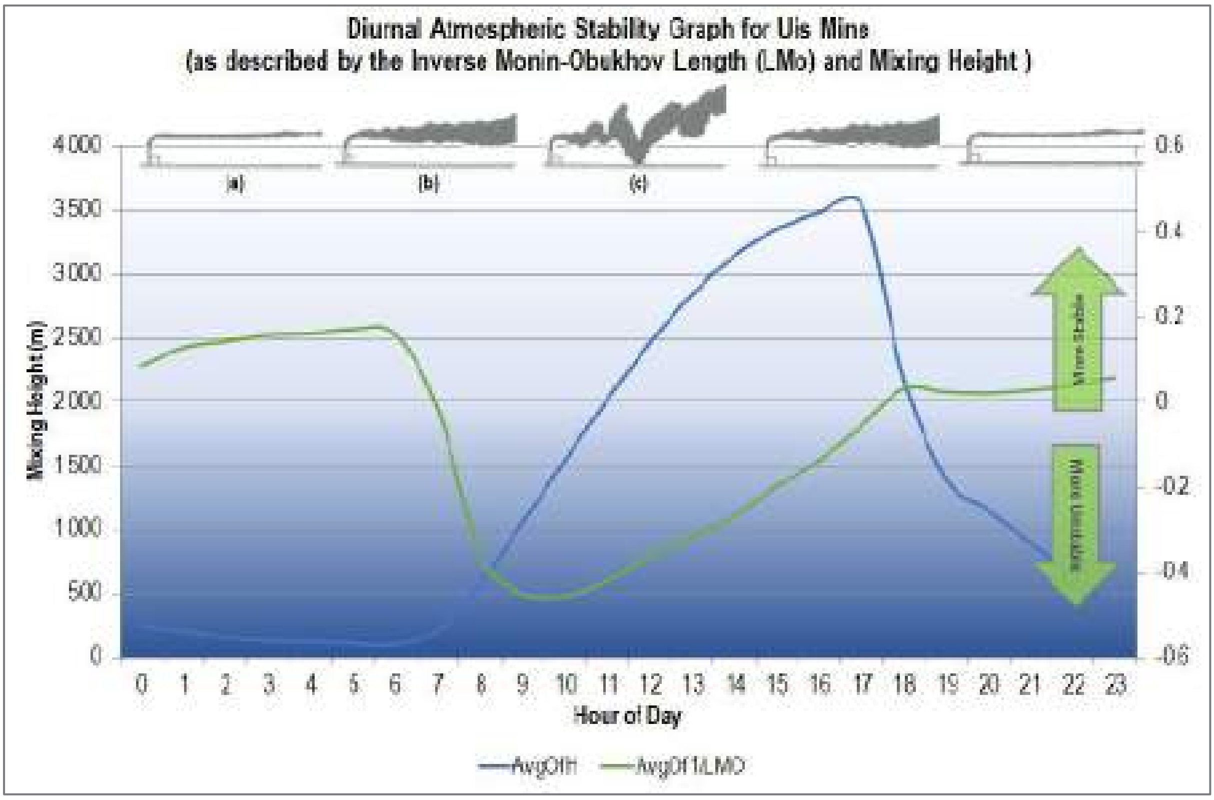

Figure 9: Diurnal atmospheric stability based on WRF modelled data (Jan 2018 – Dec 2020)

3.3 Current Ambient Air Quality

3.3.1 Existing Sources of Emissions in the Area

3.3.1.1 Atmospheric Emissions

The land in Uis area is mainly communal land used for small stock farming with tourism, small-scale mining, and operations at the UTMC generating the main sources of income. Additional sources of dust emissions contributing to the overall dust emissions load can be attributed to the activities of the Namclay Brick and Pavers factory and dust generated from historically mined areas. Given these activities, it is expected that fugitive dust may be present during dry, windy conditions.

Vehicles travelling on the nearby national, district and secondary roads release CO_2, CO, NOx, PM, SO_2 and VOC emission. These vehicles are also responsible for wheel-entrained dust.

Other potential sources of air pollution include

- Residential use of wood for heating and cooking purposes;
- Biomass burning (veld fires);
- De-bushing to increase the grazing capacity of farmland;
- Windblown dust from exposed surfaces and unpaved roads; and
- Charcoal making by heating wood (or other organic substances) in the absence of oxygen

These sources are mainly associated with the release of airborne particulates, although combustion sources would also emit carbon dioxide, carbon monoxide, oxides of nitrogen, sulphur dioxide and volatile organic compounds.

Another source of air pollution is aerosols as a result of regional-scale transport of mineral dust and ozone (due to vegetation burning) from the north of Namibia (http://www.fao.org/docrep/005/x9751e/x9751e06.htm).

3.3.2 Existing Ambient Air Pollutant Concentrations in the Project Area

The monitoring network in place at the Uis Project does not include ambient monitoring locations. PM concentrations measured as part of the SEMP AQMP monitoring network were limited to the coastal towns of Swakopmund, Walvis Bay and Henties Bay with a station in the central western part of the region on the farm Jakalswater. None of these locations are representative of the air quality in the Uis area.

3.3.3 Dustfall Monitoring Data for the Uis Tin Mine Project

Dustfall monitoring data was provided for the period March 2019 to August 2021. The monitoring network comprised of eight (8) single dustfall units between March 2019 and November 2020 but expanded to fourteen (14) single dustfall units from December 2020 forward. The locations of the dustfall stations are shown in Figure 11.

Dustfall deposition rates from the Uis monitoring network are presented in Figure 10. Dustfall rates are generally low for the sampling period and well within the dustfall limit of 600 mg/m²/day (adopted limit for residential areas) and 1 200 mg/m²/day (adopted limit for non-residential areas), with the exception of AQ 01 (5 exceedances in 2020 and 4 exceedances in 2021), AQ 05 (2 exceedances in 2019, 5 exceedances in 2020 and 1 exceedance in 2021), AQ 08 (1 exceedance in 2019) and AQ 14 (1 exceedance in 2020) (Figure 10).

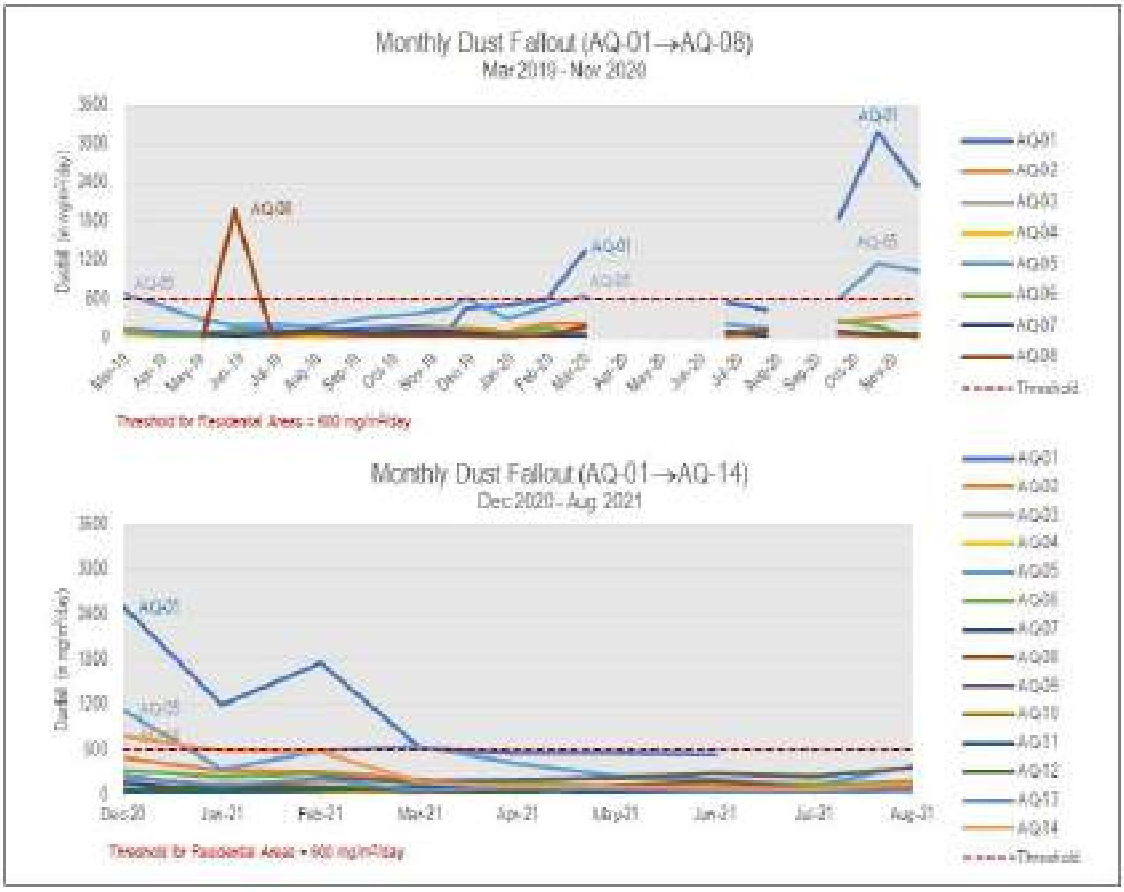

Figure 10: Dustfall rates for Uis Mine monitoring (March 2019 – August 2021)

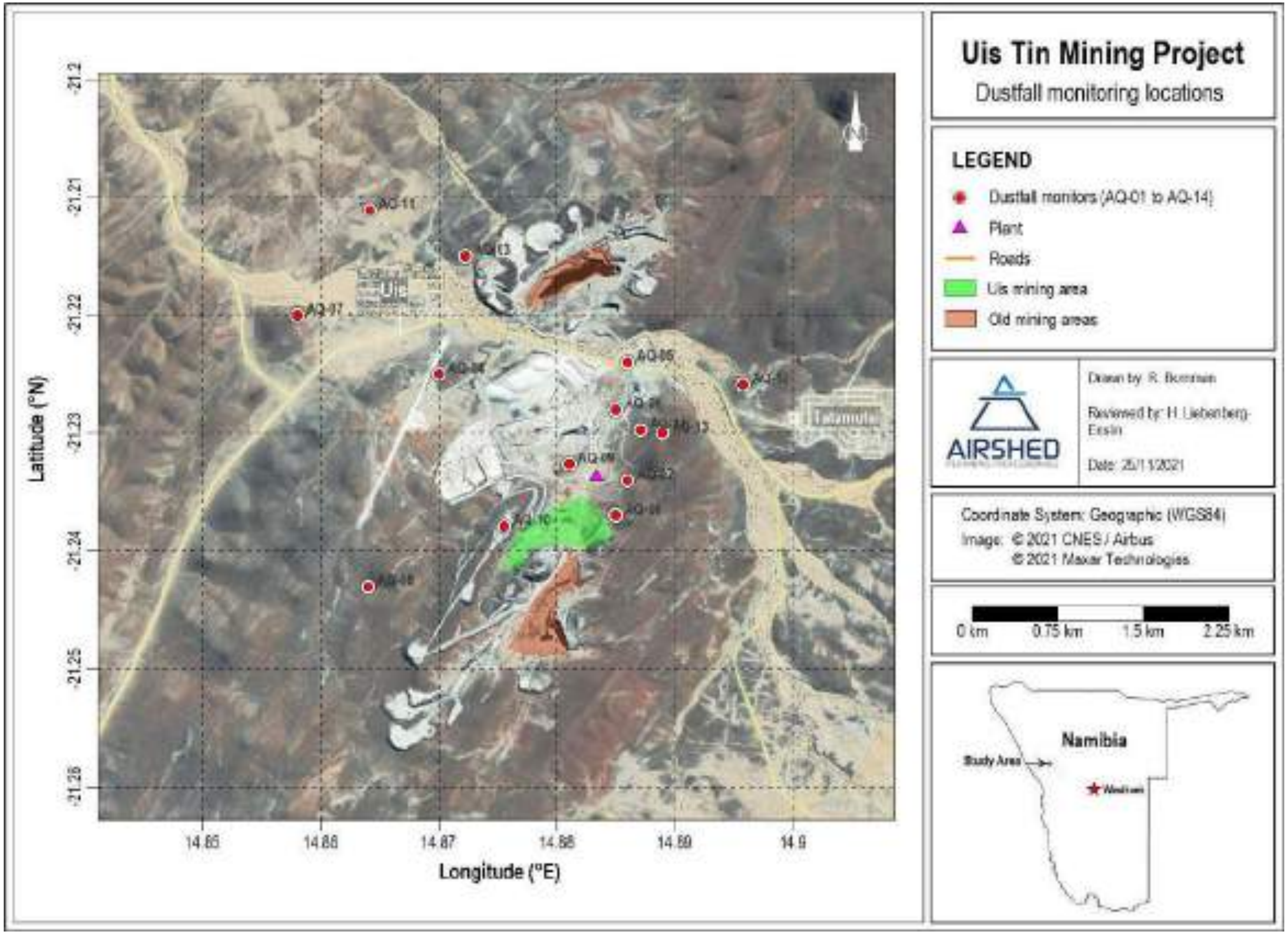

Figure 11: Uis Mine monitoring network

4 IMPACT OF PROPOSED PROJECT ON THE RECEIVING ENVIRONMENT

4.1 Atmospheric Emissions

4.1.1 Construction Phase

The construction phase during Stage II is designed to allow pre-assembly while the plant is in operation. Construction work packages include civil works, in-plant erection, piping, erection of conveyors and gantries, conveyor mechanical installation, and electrical, control and instrumentation work. Typical sources of fugitive particulate emissions associated with construction are given in Table 6.

Table 6: Typical sources of fugitive particulate emission associated with construction

Impact	Source	Activity
Gaseous emissions (SO_2, NO_x, CO, CO_2)	Vehicle tailpipes	Transport and general construction activities
Fumes (Volatile Organic Compounds -VOCs)	Construction materials (paints, solvents, oil and grease) and waste	Handling and storage
Dustfall, PM_{10} and $PM_{2.5}$	Construction of DMS feed stockpile, secondary screen and secondary crushing plant	Clearing of groundcover
		Levelling of area
		Wind erosion from open areas
		Materials handling

Each of the operations in Table 6 has their own duration and potential for dust generation. It is therefore often necessary to estimate area wide construction emissions, without regard to the actual plans of any individual construction process. Emissions were calculated for general infrastructure construction activities during the construction period, which is estimated to last 6 months.

The US-EPA documents emissions factors which aim to provide a general rule-of-thumb as to the magnitude of emissions which may be anticipated from construction operations. The quantity of dust emissions is assumed to be proportional to the area of land being worked and the level of construction activity. The approximate emission factors for general construction activity operations are given as:

E = 2.69 Mg/hectare/month of activity (269 g/m²/month)

The PM_{10} fraction is given as ~39% of the US-EPA total suspended particulate factor. These emission factors are most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents, and (iii) semiarid climates. The emission factor for TSP considers 42 hours of work per week of construction activity. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters. Because the above emission factor is referenced to TSP, use of this factor to estimate particulate matter (PM) no greater than 10 µm in aerodynamic diameter (PM_{10}) emissions will result in conservatively high estimates. Also, because derivation of the factor assumes that construction activity occurs 30 days per month, the above estimate is somewhat conservatively high for TSP as well.

The following areas (in hectare) were estimated from the proposed plant layout (see Inset area in Figure 2 and Figure 13).

DMS feed stockpile	0.0018	ha
Secondary screen	0.0077	ha
Secondary crushing plant	0.1225	ha
Total	**0.132**	**ha**

The total land area extends over 0.132 hectares, and the resultant emissions over the 6-month construction period were estimated at 355 kg for TSP, 138 kg for PM_{10} and 69 kg for $PM_{2.5}$.

4.1.2 Operational Phase

The Phase 1 Fast-Tracked Stage II expansion project involves increasing the throughput capacity of the MHCP by 50% from 80 tph to 120 tph, which can be achieved by modular expansion of individual circuits. It also includes a mining plan to deliver 850 ktpa ore to the upgraded MHCP, to produce 1 200 tpa of saleable tin concentrate for export. This is an increase in mining rate when compared to Phase 1 Stage I, where approximately 567 ktpa of pegmatite ore was delivered to the processing plant to produce 788 tpa of saleable tin concentrate for export.

A description of the project is provided in Section 1.3. The layout of the V1 and V2 mining areas, roads, waste dumps and co-displacement facility and plant area is shown in Figure 12. A detailed layout of the MHCP is provided in Figure 13. A high-level block flow diagram (BFD) describing the flow of materials at the MHCP is shown in Figure 14 (AfriTin Mining, 2021 p 73).

To determine the significance of air pollution impacts from the Project, emissions were estimated for a Baseline scenario (based on Stage I throughputs) and a Project scenario (based on Stage II throughputs).

4.1.2.1 Project throughputs

The throughputs that were used to calculate emissions for the Baseline and Project scenarios are provided in Table 7 (mining inventory) and Table 8 (MHCP inventory).

Table 7: Mining throughputs used in the emissions inventory (in tph and tpa)

	Baseline		Project	
	tph	tpa	tph	tpa
Ore Zone 1 (V1) (a)	37	323 190	55	484 500
Ore Zone 2 (V2) (a)	28	243 810	42	365 500
Waste Zone 1 (V1) (b)	71	620 525	106	930 240
Waste Zone 2 (V2) (b)	53	468 115	80	701 760
Strip ratio (c)		1.92		1.92
ROM stockpile (d)		204 935		307 222
Tin concentrate (e)		720		1 200

Notes:

(a) Calculated using a 57% to 43% split for ore extracted from V1 and V2 opencast areas (AfriTin Mining, 2021 p7)

(b) Calculated using strip ratio of 1.92 (average over LoM) (AfriTin Mining, 2021 p51)

(c) Average strip ratio over LoM (18 years)

(d) Average stockpile closing balance over LoM (AfriTin Mining, 2021 Figure 36)

(e) Tin concentrate product increased from 60 tpm (720 tpa) for the Baseline scenario to 100 tpm (1200 tpa) for the Project scenario (Phase 1 Stage II Fast-Tracked Expansion project description)

Table 8: Plant throughputs used in the emissions inventory (in tph and tpa)

	Baseline		Project		Ratio (a)
	tph	tpa	tph	tpa	
ROM Tip		567 000 (b)		850 000 (b)	
Primary crusher	80 (b)	567 000	120 (b)	850 000	1
Secondary screening (initial + return)	137	969 570	205	1 453 500	1.71
Secondary crusher	57	402 570	85	603 500	0.71
Crushed ore stockpile Tip	54	385 560	82	578 000	0.68
Tertiary screening (initial + return)	103	731 430	155	1 096 500	1.29
Tertiary crusher	9	62 370	13	93 500	0.11
Fines screening (initial + return)	128	907 200	192	1 360 000	1.6
Fines crusher	136	963 900	204	1 445 000	1.7
DMS feed bin	43	306 180	65	459 000	0.54
DMS feed stockpile Tip			65	459 000	0.54
Discard Tip and hauling (to CPF)	50	351 540	74	527 000	0.62

Notes:

(a) Ratios were calculated from material streams provided in the BFD for the Phase 1 Stage II Fast-Tracked Expansion project (Figure 14) (AfriTin Mining, 2021 p73)

(b) See description in Section 4.1.2

4.1.2.2 Emissions Inventory

Two operational scenarios were assessed, viz. the Baseline and Project scenarios, each with an unmitigated and mitigated sub-scenario.

Emissions inventories provide the source input required for the simulation of ambient air concentrations. In the quantification of these releases use was made of the predictive emission factors published by the US-EPA (EPA, 1996) and Australian NPi (Australian NPi Manual for Mining, 2012), since no local emission factors are available. The emission equations are provided in Table 9. The particle size distributions assumed for overburden, ROM and CPF material (used in the calculation of emissions due to windblown dust from the proposed stockpiles and co-placement facility) are listed in Table 10 and Table 11. The control efficiencies used in the calculation of emissions due to mitigated operations are listed in Table 12 – these were based on design mitigation measures assumed for the Project.

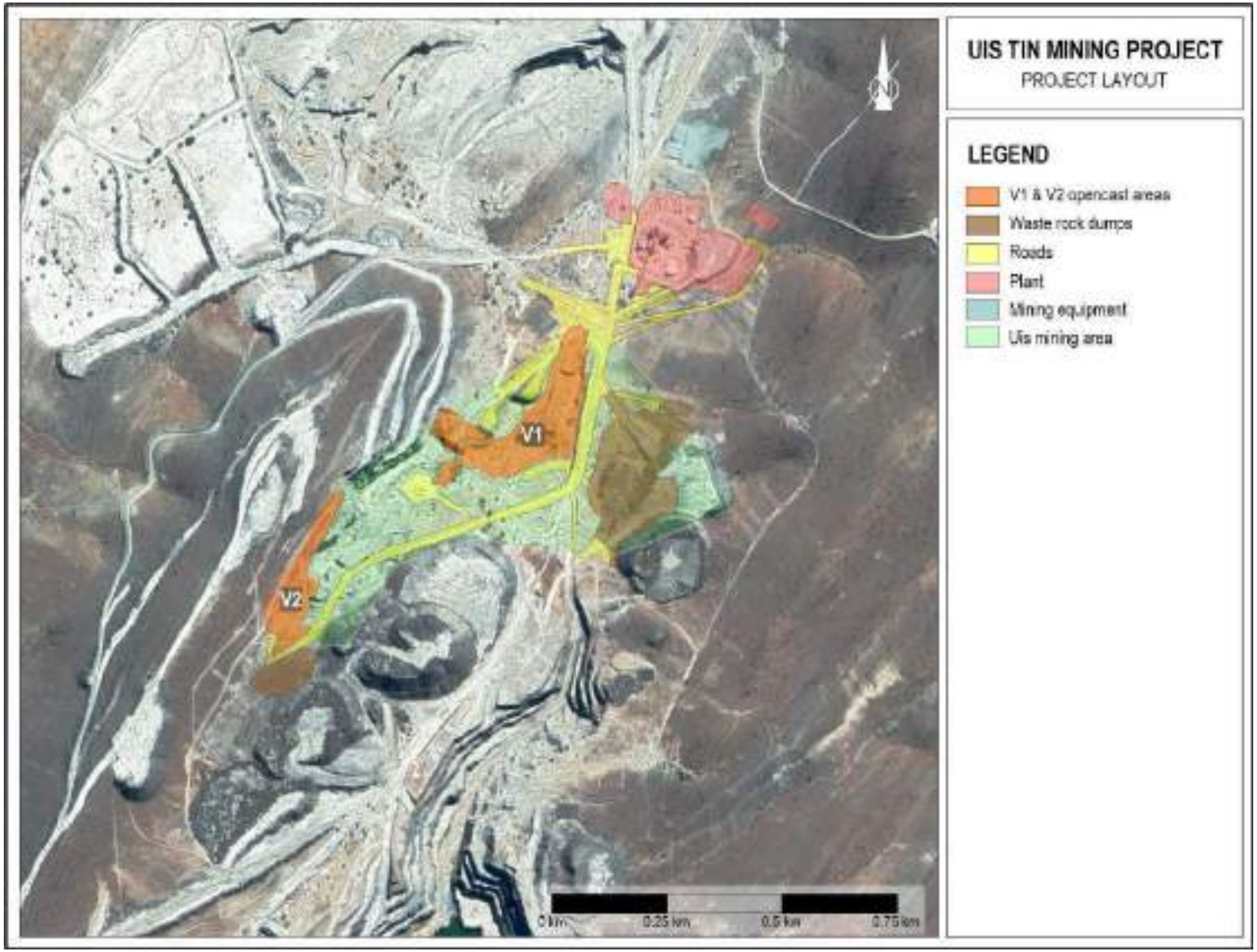

Figure 12: Project Layout

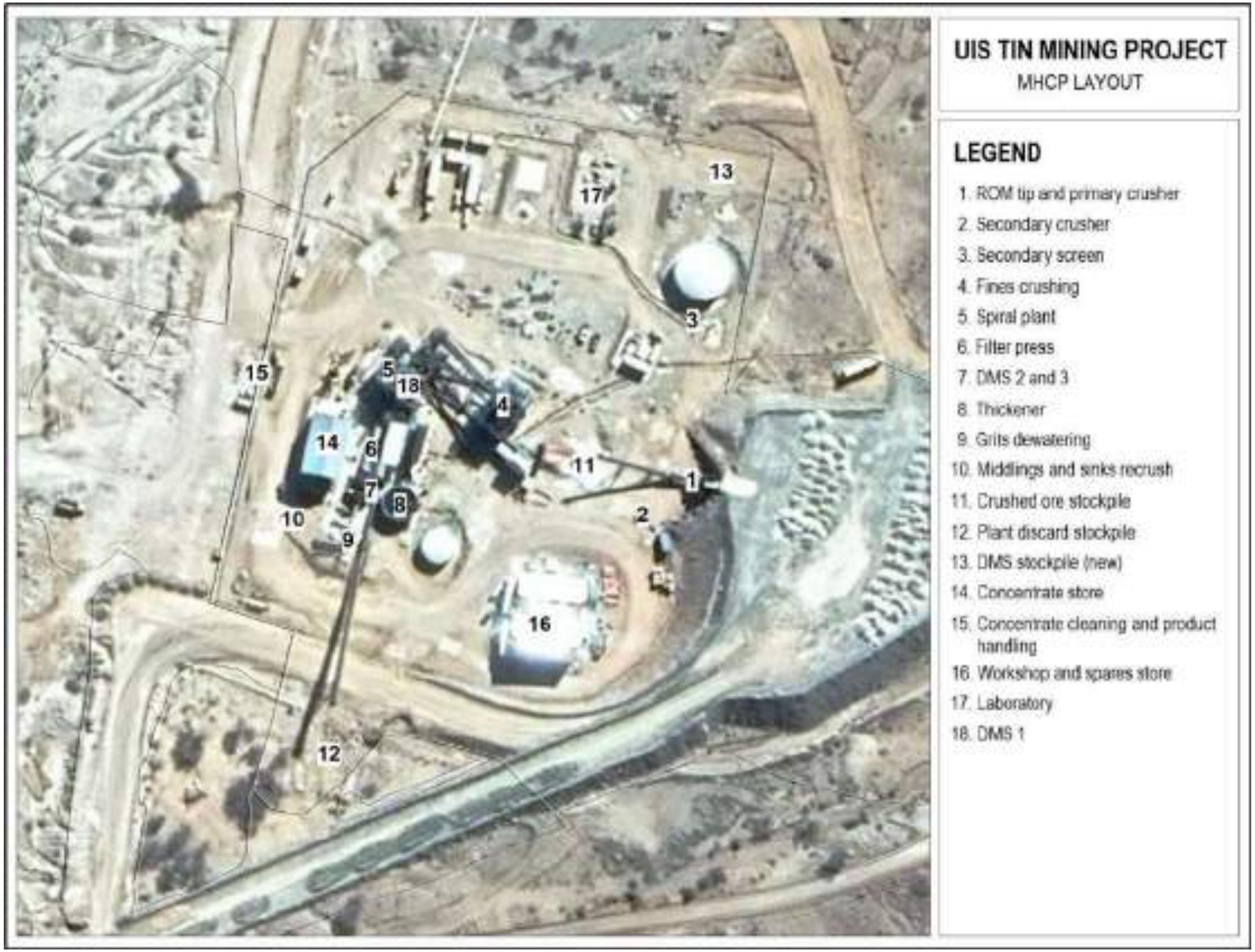

Figure 13: MHCP Layout

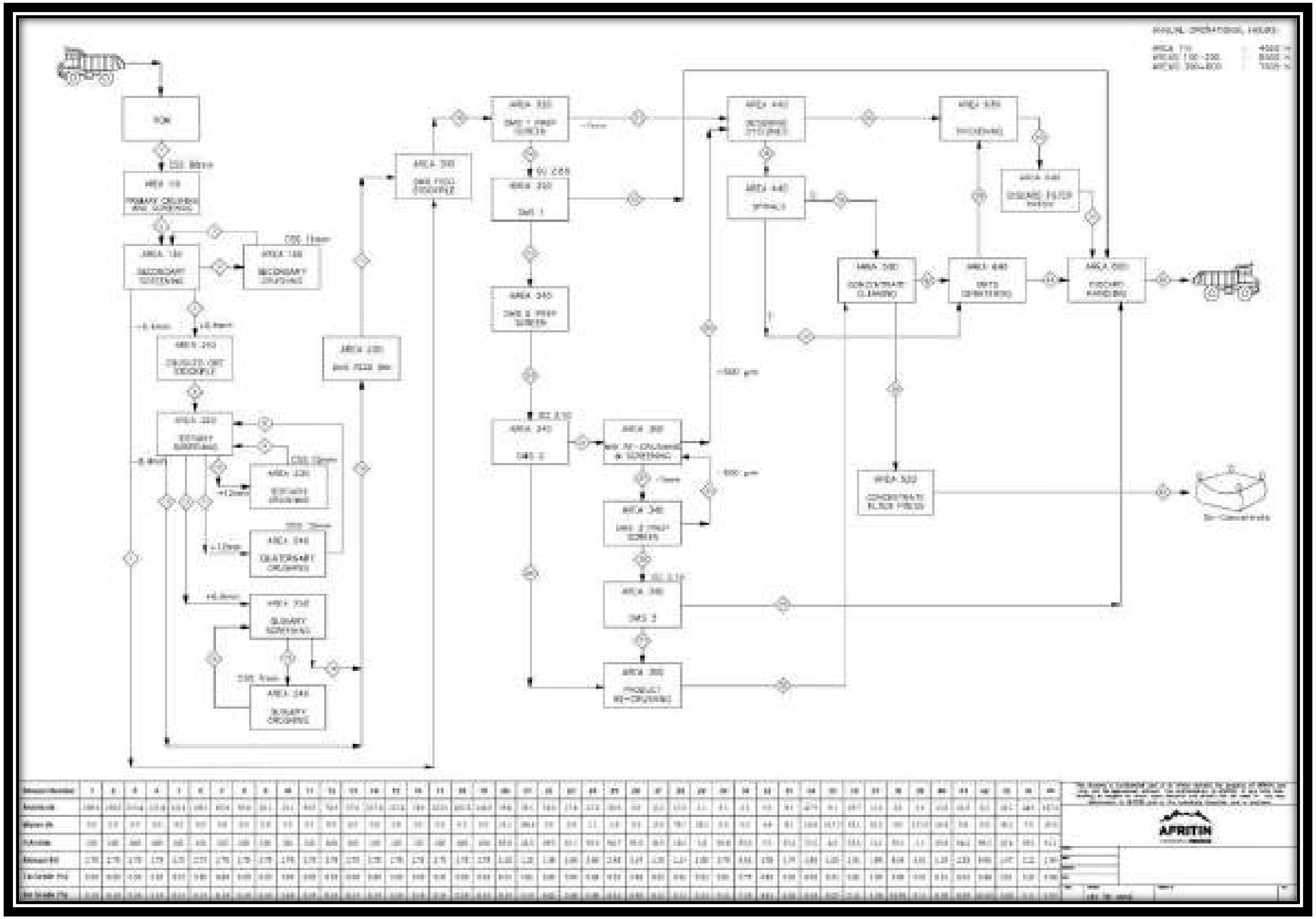

Figure 14: Simplified block flow diagram for the proposed Phase 1 Fast-Tracked Stage II Expansion Project

Table 9: Emission equations used to quantify the routine emissions from the operational phase

Activity	Emission Equation	Source	Information assumed/provided
Vehicle entrainment on unpaved surfaces	$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}\cdot 281.9$$ Where, E = particulate emission factor in grams per vehicle km travelled (g/VKT) k = basic emission factor for particle size range and units of interest s = road surface silt content (%) W = average weight (tonnes) of the vehicles travelling the road The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$ and 1.5 for PM_{10}, and as 4.9 for TSP The empirical constant (a) is given as 0.9 for $PM_{2.5}$ and PM_{10}, and 4.9 for TSP The empirical constant (b) is given as 0.45 for $PM_{2.5}$, PM_{10} and TSP	US-EPA AP42 Section 13.2.2	In the absence of site-specific silt data, use was made of US-EPA default mean silt content of 8.4%. The capacity of the haul trucks to be used was given as 30t. Average weight of haul trucks was calculated as 37.7t. The layout of the roads was provided (Figure 12). The throughput of ROM and waste materials for the mining area is provided in Table 7 and discard throughputs given in Table 8. Operating hours were given as 24 hours per day, 7 days a week.
Materials handling	$$E = 0.0016\frac{\left(U/2.2\right)^{1.3}}{\left(M/2\right)^{1.4}}$$ Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively.	US-EPA AP42 Section 13.2.4	An average wind speed of 4.8 m/s was used based on the WRF data for the period 2018 – 2020. The throughput of ROM, overburden and discard material are as specified above (for vehicle entrainment on unpaved surfaces). The moisture content of the ROM material was assumed as 2.4% (from a Google search on pegmatite orebodies) and 15% for the discard material (from AfriTin Mining, 2021). In the absence of site-specific moisture contents, use was made of US-EPA default mean moisture contents of 7.9% for waste rock. Operating hours were given as 24 hours per day, 7 days a week for mining activities. Emissions at the plant area were calculated from the hourly throughputs provided in Table 8, and as a worst-case scenario, modelled under the assumption of continuous operations.

Activity	Emission Equation	Source	Information assumed/provided
Drilling	$E_{TSP} = 0.59\, kg/hole\ drilled$ $E_{PM_{10}} = 0.31\, kg/hole\ drilled$ $E_{PM_{2.5}} = 0.31\, kg/hole\ drilled$	NPI Section: Mining	Drill holes per day were calculated as 107 (from drilling and blasting information provided in Maritz and Uludag, 2019). Operating hours were assumed to be 24 hours per day, 7 days a week.
Blasting	$E = 0.00022 \cdot (A)^{1.5}$ Where, E = Emission factor (kg dust / t transferred) A = Blast area (m²) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively.	NPI Section: Mining	The blast area was calculated as 1500 m² (from drilling and blasting information provided in Maritz and Uludag, 2019). The number of blasts was assumed as 3 times per week (twice a week for overburden and once a week for ore). For modelling purposes it was assumed that blasting occurs over a 1-hour period on Monday, Wednesday and Saturday.
Crushing (primary and secondary)	Primary crushing: $E_{TSP} = 0.2\ kg/t\ material\ processed$ $E_{PM10} = 0.02\ kg/t\ material\ processed$ $E_{PM2.5} = 0.01\ kg/t\ material\ processed$ Secondary crushing: $E_{TSP} = 0.6\ kg/t\ material\ processed$ $E_{PM10} = 0.06\ kg/t\ material\ processed$ $E_{PM2.5} = 0.03\ kg/t\ material\ processed$ Where, E = Default emission factor for low moisture content ore Fraction of $PM_{2.5}$ assumed as 50% of PM_{10}	US-EPA AP42 Section 11.24.2	Primary and secondary crushing emissions were calculated from the hourly throughputs provided in Table 8, and, as a worst-case scenario, modelled under the assumption of continuous operations. For mitigated baseline operations, 50% CE was assumed for primary and secondary crushing (water suppression). For mitigated Project operations, 99% CE was assumed for primary and secondary crushing (dual scrubber).
Crushing (tertiary)	Tertiary crushing (uncontrolled): $E_{TSP} = 0.0027\ kg/t\ material\ processed$ $E_{PM10} = 0.0012\ kg/t\ material\ processed$ $E_{PM2.5} = 0.0002\ kg/t\ material\ processed$	US-EPA AP42 Section 11.19.2	Throughputs: Hourly throughputs provided in Table 8. Operational hours: Assumed to be continuous (as a worst-case scenario) for dispersion modelling purposes.

Activity	Emission Equation	Source	Information assumed/provided
	Tertiary crushing (controlled): $$E_{TSP} = 0.0006\ kg/t\ material\ processed$$ $$E_{PM10} = 0.00027\ kg/t\ material\ processed$$ $$E_{PM2.5} = 0.00005\ kg/t\ material\ processed$$ Where, Fraction of $PM_{2.5}$ for uncontrolled operations calculated from $PM_{2.5}$ and PM_{10} factors given for controlled tertiary crushing operations	Section 11.19.2.2	Emission controls due to crushed stone processing are discussed in US-EPA AP42 Section 11.19.2.2 and emission factors for controlled tertiary crushing operations given in Table 11.19.2-1.
Crushing (fines)	Fines crushing (uncontrolled): $$E_{TSP} = 0.0195\ kg/t\ material\ processed$$ $$E_{PM10} = 0.0075\ kg/t\ material\ processed$$ $$E_{PM2.5} = 0.0004\ kg/t\ material\ processed$$ Fines crushing (controlled): $$E_{TSP} = 0.0015\ kg/t\ material\ processed$$ $$E_{PM10} = 0.0006\ kg/t\ material\ processed$$ $$E_{PM2.5} = 0.000035\ kg/t\ material\ processed$$ Where, Fraction of $PM_{2.5}$ for uncontrolled operations calculated from $PM_{2.5}$ and PM_{10} factors given for controlled fines crushing operations	US-EPA AP42 Section 11.19.2 Section 11.19.2.2	Throughputs: Hourly throughputs provided in Table 8. Operational hours: Assumed to be continuous (as a worst-case scenario) for dispersion modelling purposes. Emission controls due to crushed stone processing are discussed in US-EPA AP42 Section 11.19.2.2 and emission factors for controlled fines crushing operations given in Table 11.19.2-1.
Screening (secondary)	Secondary screening (uncontrolled): $$E_{TSP} = 0.0125\ kg/t\ material\ processed$$ $$E_{PM10} = 0.0043\ kg/t\ material\ processed$$ $$E_{PM2.5} = 0.0003\ kg/t\ material\ processed$$ Secondary screening (controlled): $$E_{TSP} = 0.0011\ kg/t\ material\ processed$$ $$E_{PM10} = 0.00037\ kg/t\ material\ processed$$ $$E_{PM2.5} = 0.000025\ kg/t\ material\ processed$$ Where,	US-EPA AP42 Section 11.19.2 Section 11.19.2.2	Throughputs: Hourly throughputs provided in Table 8. Operational hours: Assumed to be continuous (as a worst-case scenario) for dispersion modelling purposes. Emission controls due to crushed stone processing are discussed in US-EPA AP42 Section 11.19.2.2 and emission factors for controlled screening operations given in Table 11.19.2-1.

Activity	Emission Equation	Source	Information assumed/provided
	Fraction of $PM_{2.5}$ for uncontrolled operations calculated from $PM_{2.5}$ and PM_{10} factors given for controlled screening operations		
Screening (fines)	Fines screening (uncontrolled): $$E_{TSP} = 0.15\ kg/t\ material\ processed$$ $$E_{PM10} = 0.036\ kg/t\ material\ processed$$ $$E_{PM2.5} = 0.0024\ kg/t\ material\ processed$$ Fines screening (controlled): $$E_{TSP} = 0.0018\ kg/t\ material\ processed$$ $$E_{PM10} = 0.0011\ kg/t\ material\ processed$$ $$E_{PM2.5} = 0.0001\ kg/t\ material\ processed$$ Where, Fraction of $PM_{2.5}$ for uncontrolled operations calculated from $PM_{2.5}$ and PM_{10} factors given for controlled fines screening operations	US-EPA AP42 Section 11.19.2 Section 11.19.2.2	Throughputs: Hourly throughputs provided in Table 8. Operational hours: Assumed to be continuous (as a worst-case scenario) for dispersion modelling purposes. Emission controls due to crushed stone processing are discussed in US-EPA AP42 Section 11.19.2.2 and emission factors for controlled fines screening operations given in Table 11.19.2-1
Wind Erosion	$$E(i) = G(i)10^{(0.134(\%clay)-6)}$$ For $$G(i) = 0.261\left[\frac{P_a}{g}\right]u^{*3}(1+R)(1-R^2)$$ And $$R = \frac{u_*^{\ t}}{u^*}$$ where, $E_{(i)}$ = emission rate (g/m²/s) for particle size class i P_a = air density (g/cm³) G = gravitational acceleration (cm/s³) u_*^{t} = threshold friction velocity (m/s) for particle size i u^* = friction velocity (m/s)	Marticorena & Bergametti, 1995	ROM, waste rock and co-disposal particle size distributions were obtained from similar processes (see Table 10 and Table 11). The moisture content and particle density of ROM material was assumed as 2.4% and 1.78 t/m³ respectively (from similar processes). The moisture content and particle density of waste rock material was assumed as 2% and 2.20 t/m³ respectively (from similar processes). The moisture content and particle density of co-disposal material was assumed as 3.4% and 2.05 t/m³ respectively (from similar processes). Layout of ROM, WRD stockpiles and CPF was provided. Hourly emission rate files were calculated and simulated.

Table 10: Particle size distribution of waste rock material (given as a fraction)

Waste Rock	
Size µm	Mass Fraction
76.32	0.101
65.51	0.183
48.27	0.213
30.53	0.144
19.31	0.130
10.48	0.091
5.69	0.073
2.65	0.064

Table 11: Particle size distributions of co-placement and ROM material (given as a fraction)

Co-disposal facility		ROM Stockpiles	
Size µm	Mass Fraction	Size µm	Mass Fraction
4000.00	0.1257	4000	0.3213
2000.00	0.0399	2000	0.0990
555.71	0.0008	555.71	0.0000
477.01	0.0104	477.01	0.0031
409.45	0.0226	409.45	0.0063
351.46	0.0348	351.46	0.0092
301.68	0.0450	301.68	0.0115
258.95	0.0518	258.95	0.0130
222.28	0.0552	222.28	0.0142
190.80	0.0554	190.8	0.0151
163.77	0.0531	163.77	0.0159
140.58	0.0502	140.58	0.0169
120.67	0.0472	120.67	0.0179
103.58	0.0441	103.58	0.0190
88.92	0.0412	88.91	0.0201
56.23	0.0355	76.32	0.0209
48.27	0.0323	65.51	0.0217
41.43	0.0293	56.23	0.0223
35.56	0.0263	48.27	0.0225
30.53	0.0237	41.43	0.0225
26.20	0.0211	35.56	0.0222
22.49	0.0187	30.53	0.0217
19.31	0.0166	26.2	0.0211
16.57	0.0146	22.49	0.0204
14.22	0.0130	19.31	0.0197
12.21	0.0114	16.57	0.0190
10.48	0.0102	14.22	0.0182
9.00	0.0091	12.21	0.0174
7.73	0.0081	10.48	0.0165

Co-disposal facility		ROM Stockpiles	
Size µm	Mass Fraction	Size µm	Mass Fraction
5.69	0.0068	9	0.0156
4.88	0.0061	7.72	0.0146
4.19	0.0053	6.63	0.0134
3.60	0.0048	5.69	0.0122
3.09	0.0043	4.88	0.0110
2.65	0.0039	4.19	0.0098
2.28	0.0034	3.6	0.0086
1.95	0.0031	3.09	0.0076
1.68	0.0028	2.65	0.0067
1.24	0.0023	2.28	0.0059
1.06	0.0020	1.95	0.0050
0.91	0.0018	1.68	0.0043
0.78	0.0015	1.44	0.0037
0.67	0.0012	1.24	0.0031
0.49	0.0009	1.06	0.0026
0.42	0.0008	0.91	0.0020
0.36	0.0006	0.78	0.0015
0.31	0.0005	0.67	0.0012
0.27	0.0003	0.58	0.0008
0.23	0.0002	0.49	0.0006
0.20	0.0001	0.42	0.0004
0.17	0.0001	0.36	0.0003
0.15	0.0000	0.31	0.0002
0.13	0.0001	0.27	0.0001
0.11	0.0001	0.23	0.0001
		0.2	0.0001
		0.17	0.0001
		0.15	0.0001
		0.13	0.0001
		0.11	0.0001
		0.09	0.0001
		0.08	0.0001
		0.07	0.0000
		0.06	0.0000

Table 12: Estimated control factors for various mining operations

Operation/Activity	Control method and emission reduction
Drilling	No control
Blasting	No control
Materials handling (loading and unloading, conveyor transfer)	50% CE for water suppression
Primary and secondary crushing (Baseline)	50% CE for water suppression
Primary and secondary crushing (Project)	99% CE on primary and secondary crushing (for dual scrubber)
Tertiary crushing	78% CE (wet process)
Fines crushing	92% CE (wet process)
Secondary and fines screening	90% CE and 97% CE respectively (wet process)
Hauling	75% for water sprays on surface roads, 50% CE for water sprays on in-pit roads
Wind erosion from exposed surfaces	No control

4.1.3 Summary of Emissions due to Baseline and Project Scenarios

Summaries of particulate emissions for routine operations due to the Baseline and Project scenarios are provided in Table 13.

The contributions of individual source groups to total tons per annum for the Baseline and Project scenarios are illustrated in Figure 15 (a-b) and Figure 15 (c-d) respectively.

Table 13: Calculated emission rates due to unmitigated and mitigated activities for the Baseline and Project scenarios respectively

Description	Baseline Scenario						Project Scenario					
	Unmitigated			Mitigated			Unmitigated			Mitigated		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
In-pit (including drilling)	51.34	75.99	186.41	49.91	62.24	139.35	52.76	89.71	233.38	50.62	69.10	162.84
Blasting	0.06	1.04	24.40	0.06	1.04	24.40	0.06	1.04	24.40	0.06	1.04	24.40
Materials handling	0.72	4.74	10.01	0.36	2.37	5.01	1.32	8.74	18.47	0.54	3.55	7.51
Crushing and screening	16.85	85.84	572.61	7.00	15.93	182.35	25.27	112.01	796.40	0.43	3.74	12.80
Unpaved roads	8.77	87.69	306.84	2.19	21.92	76.71	13.15	131.46	459.99	3.29	32.86	115.00
Wind erosion	3.59	12.97	49.91	3.59	12.97	49.91	3.59	12.97	49.91	3.59	12.97	49.91
Total	**81**	**266**	**1141**	**63**	**114**	**468**	**96**	**354**	**1573**	**58**	**121**	**363**

Notes:

(a) BASELINE: Mitigation includes 75% control efficiency (CE) on unpaved surface roads and 50% CE on unpaved in-pit roads (using water sprays), 50% CE on primary and secondary crushing and materials handling operations (using water sprays), >75% CE for tertiary and fines crushing and screening (wet process)

(b) PROJECT: Mitigation includes all control measures listed in (a), but with 99% CE on primary and secondary crushing operations (dual scrubber).

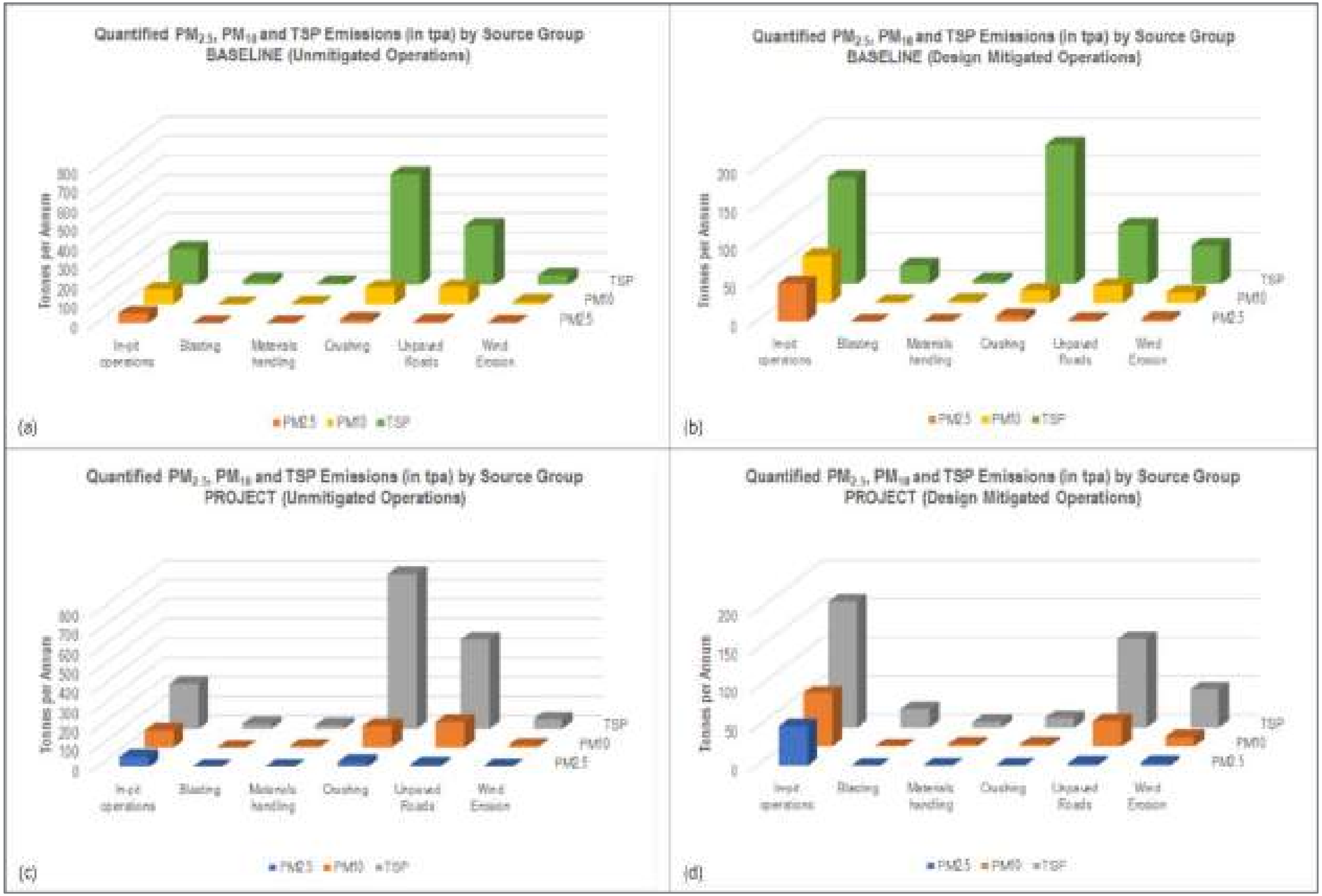

Figure 15: Contribution of particulate emissions per source group

4.2 Atmospheric Dispersion Modelling

The impact of proposed operations on the atmospheric environment was determined through the simulation of ambient pollutant concentrations. Dispersion models simulate ambient pollutant concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements. It is therefore important to carefully select a dispersion model for the purpose.

4.2.1 Dispersion Model Selection

In the simulation of ambient air pollutant concentrations use was made of the ADMS 5 model (Atmospheric Dispersion Modelling System version 5.0.0) developed by the Cambridge Environmental Research Consultants (CERC). This model simulates a wide range of buoyant and passive releases to the atmosphere either individually or in combination. It has been the subject of several inter-model comparisons (CERC, 2004) (Hall, et al., 2000), one conclusion of which is that it tends provide conservative values under unstable atmospheric conditions in that, in comparison to the older regulatory models, it predicts higher concentrations close to the source.

The ADMS model was chosen specifically for its capability of modelling flow over complex topography, to account for the local topographical features in the Project region.

4.2.2 Meteorological Requirements

For the current study, use was made of modelled WRF data for the period 2018-2020.

4.2.3 Source Data Requirements

The ADMS model can model point, jet, area, line and volume sources. Materials handling and crushing sources were modelled as volume sources. The following emissions sources were modelled as area sources:

- Open pit;
- Blasting;
- Roads;
- Stockpiles (wind erosion);
- Co-placement facility (wind erosion).

4.2.4 Modelling Domain

The dispersion of pollutants expected to arise from proposed activities was modelled for an area covering 10 km (east-west) by 10 km (north-south). The area was divided into a grid matrix with a resolution of 100 m, with the Project located centrally. The surrounding receptors were included as discrete receptors (see Figure 2). ADMS calculates ground-level (1.5 m above ground level) concentrations at each grid and discrete receptor point.

4.2.5 Complex Terrain

Topography was included in dispersion simulations. The effect of complex terrain is modelled in ADMS by changing the plume trajectory and dispersion to account for disturbances in the air flow due to terrain (CERC, 2004). Readily available terrain data was obtained from the Atmospheric Studies Group (ASG) via the United States Geological Survey (USGS) web site (ASG, 2011).

4.3 Dispersion Modelling Results

Dispersion modelling was undertaken to determine highest daily and annual average ground level concentrations (GLCs). Averaging periods were selected to facilitate the comparison of predicted pollutant concentrations to relevant ambient air quality and inhalation health criteria as well as dustfall regulations.

Pollutants with the potential to result in human health impacts which are assessed in this study include $PM_{2.5}$ and PM_{10}. Dustfall is assessed for its nuisance potential. Results are primarily provided in form of isopleths to present areas of exceedance of assessment criteria. Ground level concentration or dustfall isopleths presented in this section depict interpolated values from the concentrations simulated by ADMS 5 for each of the receptor grid points specified.

Isopleth plots reflect the incremental GLCs for $PM_{2.5}$ and PM_{10} where exceedances of the relevant Air Quality Objectives (AQOs) were simulated. The proposed AQOs as set out in Table 5 are used as indicators during the assessment.

It should also be noted that ambient air quality criteria apply to areas where the Occupational Health and Safety regulations do not apply, thus outside the property or lease area. Ambient air quality criteria are therefore not occupational health indicators but applicable to areas where the general public has access, viz. off-site.

4.3.1 PM_{10}

4.3.1.1 Baseline Scenario

The simulated exceedances of highest daily and annual average PM_{10} AQOs for unmitigated and mitigated Baseline operations are provided in Figure 16 and Figure 17 respectively, with the GLCs at the nearest AQSRs provided in Table 14.

PM_{10} daily GLCs, for unmitigated activities, result in exceedances of the 24-hour air quality objective (AQO) over a maximum distance of ~700 m from Uis mining activities, but with no exceedances at any of the AQSRs. For mitigated activities, impacts are limited to the Uis mining and processing plant areas with no exceedances at any of the AQSRs. PM_{10} annual GLCs, for both unmitigated and mitigated activities, are within the AQO at the AQSRs.

4.3.1.2 Project Scenario

The simulated exceedances of highest daily and annual average PM_{10} AQOs for unmitigated and mitigated Project operations are provided in Figure 18 and Figure 19 respectively, with the GLCs at the nearest AQSRs provided in Table 14.

The daily PM_{10} AQO (WHO IT-3 and SA NAAQS) is exceeded over a maximum distance of 950 m from the Uis mining area (with no mitigation in place) but reduce to smaller areas of exceedance on-site when mitigation is applied. PM_{10} daily GLCs, for unmitigated and mitigated activities, do not result in any exceedances of the 24-hour AQO at the AQSRs. Over an annual average there are no exceedances at any of the AQSRs, without and with mitigation.

Table 14: Simulated PM_{10} ground level concentrations (in µg/m³) at selected AQSRs for BASELINE and PROJECT operations (non-compliance is highlighted)

AQSR	BASELINE						PROJECT					
	Unmitigated			Mitigated			Unmitigated			Mitigated		
	Annual Avg	Highest Day	FOE	Annual Avg	Highest Day	FOE	Annual Avg	Highest Day	FOE	Annual Avg	Highest Day	FOE
AQO	40 µg/m³	75 µg/m³	>4 days/year	40 µg/m³	75 µg/m³	>4 days/year	40 µg/m³	75 µg/m³	>4 days/year	40 µg/m³	75 µg/m³	>4 days/year
0	1.12	10.37	0	0.34	2.85	0	1.56	14.33	0	0.33	2.76	0
1	1.05	8.54	0	0.32	2.79	0	1.47	12.13	0	0.31	2.76	0
2	1.10	9.52	0	0.34	2.81	0	1.54	13.23	0	0.33	2.95	0
3	1.11	10.09	0	0.34	2.87	0	1.55	13.93	0	0.33	2.73	0
4	1.15	9.90	0	0.35	3.00	0	1.61	13.83	0	0.34	3.06	0
5	1.16	9.55	0	0.35	2.88	0	1.63	13.25	0	0.34	2.80	0
6	1.12	9.32	0	0.34	2.71	0	1.56	12.71	0	0.33	2.63	0
7	1.17	10.26	0	0.35	2.98	0	1.64	14.36	0	0.34	2.95	0
8	0.96	7.72	0	0.29	2.06	0	1.34	10.94	0	0.28	1.94	0
9	0.94	7.40	0	0.29	2.11	0	1.32	10.51	0	0.28	2.04	0
10	0.91	7.27	0	0.28	1.99	0	1.28	10.31	0	0.27	1.94	0
11	1.36	11.08	0	0.42	3.02	0	1.91	15.54	0	0.39	2.57	0
12	1.06	11.77	0	0.33	3.25	0	1.47	16.40	0	0.32	3.14	0
13	1.02	11.33	0	0.32	3.19	0	1.42	15.80	0	0.31	3.01	0
14	0.97	11.48	0	0.30	3.30	0	1.35	16.07	0	0.29	3.06	0
15	1.04	14.45	0	0.32	4.18	0	1.44	20.32	0	0.31	3.86	0
16	0.33	9.63	0	0.09	2.76	0	0.46	13.52	0	0.08	2.79	0
17	0.12	5.26	0	0.04	1.34	0	0.17	7.45	0	0.03	1.33	0
18	2.13	14.64	0	0.66	4.22	0	2.99	20.80	0	0.62	4.09	0
19	1.13	9.47	0	0.36	2.60	0	1.59	13.35	0	0.34	2.39	0
Uis Town	3.11	19.93	0	0.95	5.53	0	4.39	28.38	0	0.90	4.79	0
Uis Village	0.71	18.13	0	0.20	4.33	0	0.97	25.76	0	0.16	3.44	0
Tatamutsi	0.27	7.53	0	0.08	1.90	0	0.37	10.33	0	0.07	1.59	0

Notes:

(a) BASELINE: Mitigation includes 75% control efficiency (CE) on unpaved surface roads and 50% CE on unpaved in-pit roads (using water sprays), 50% CE on primary and secondary crushing and materials handling operations (using water sprays), >75% CE for tertiary and fines crushing and screening (wet process)

(b) PROJECT: Mitigation includes all control measures listed in (a), but with 99% CE on primary and secondary crushing operations (dual scrubber).

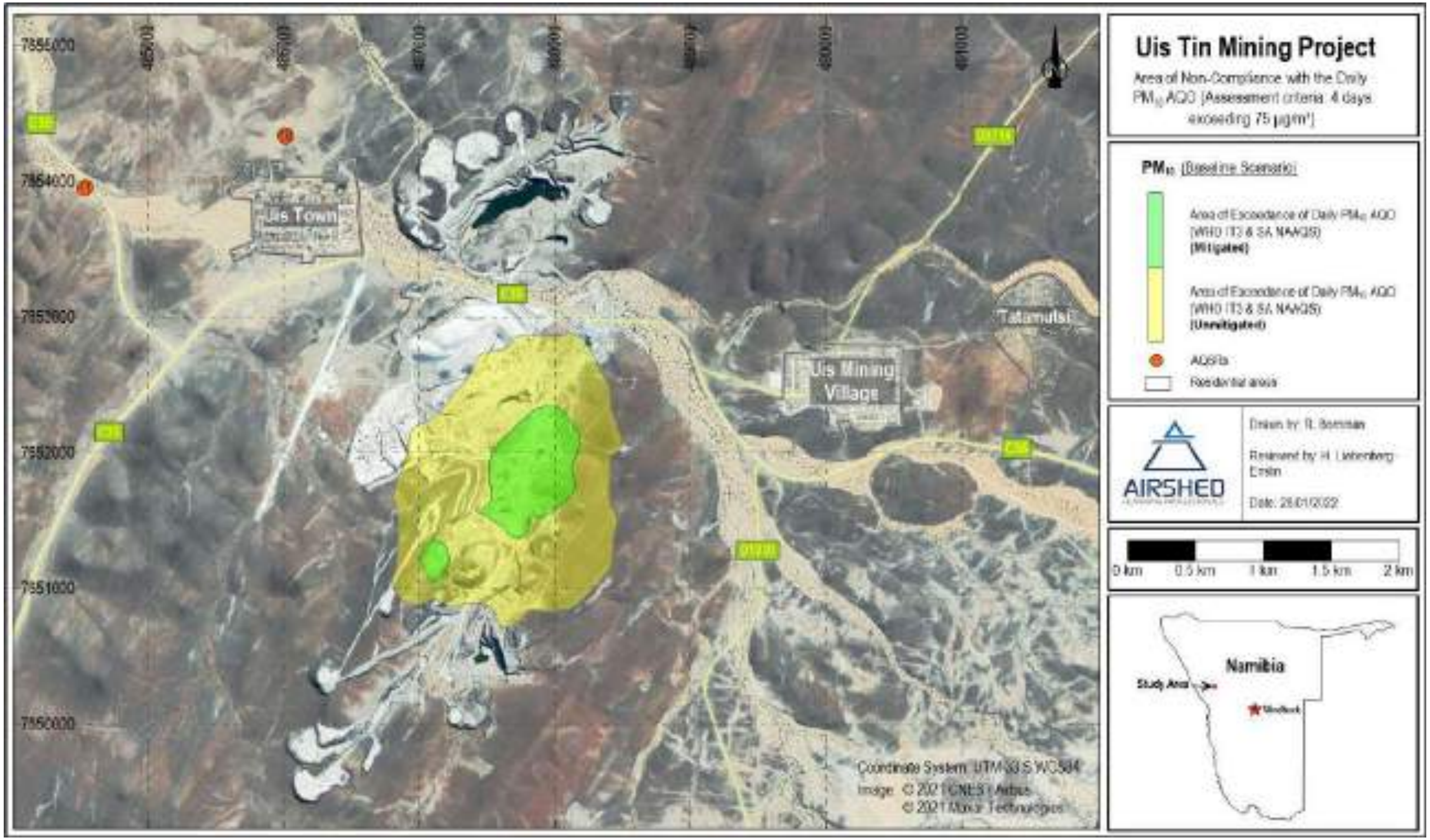

Figure 16: Area of non-compliance of <u>daily</u> PM_{10} AQO for unmitigated and mitigated Baseline operations

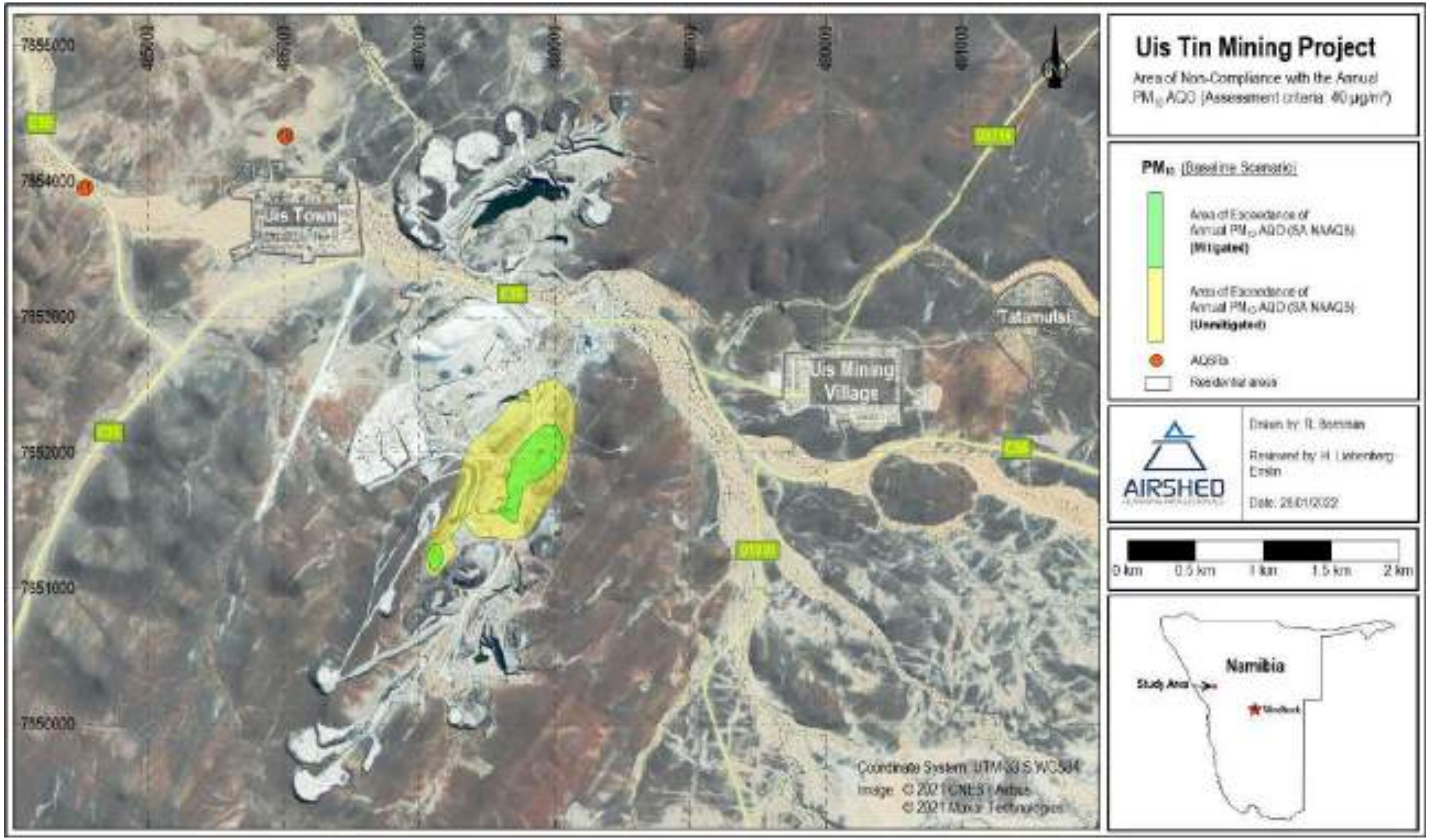

Figure 17: Area of non-compliance of annual PM_{10} AQO for unmitigated and mitigated Baseline operations

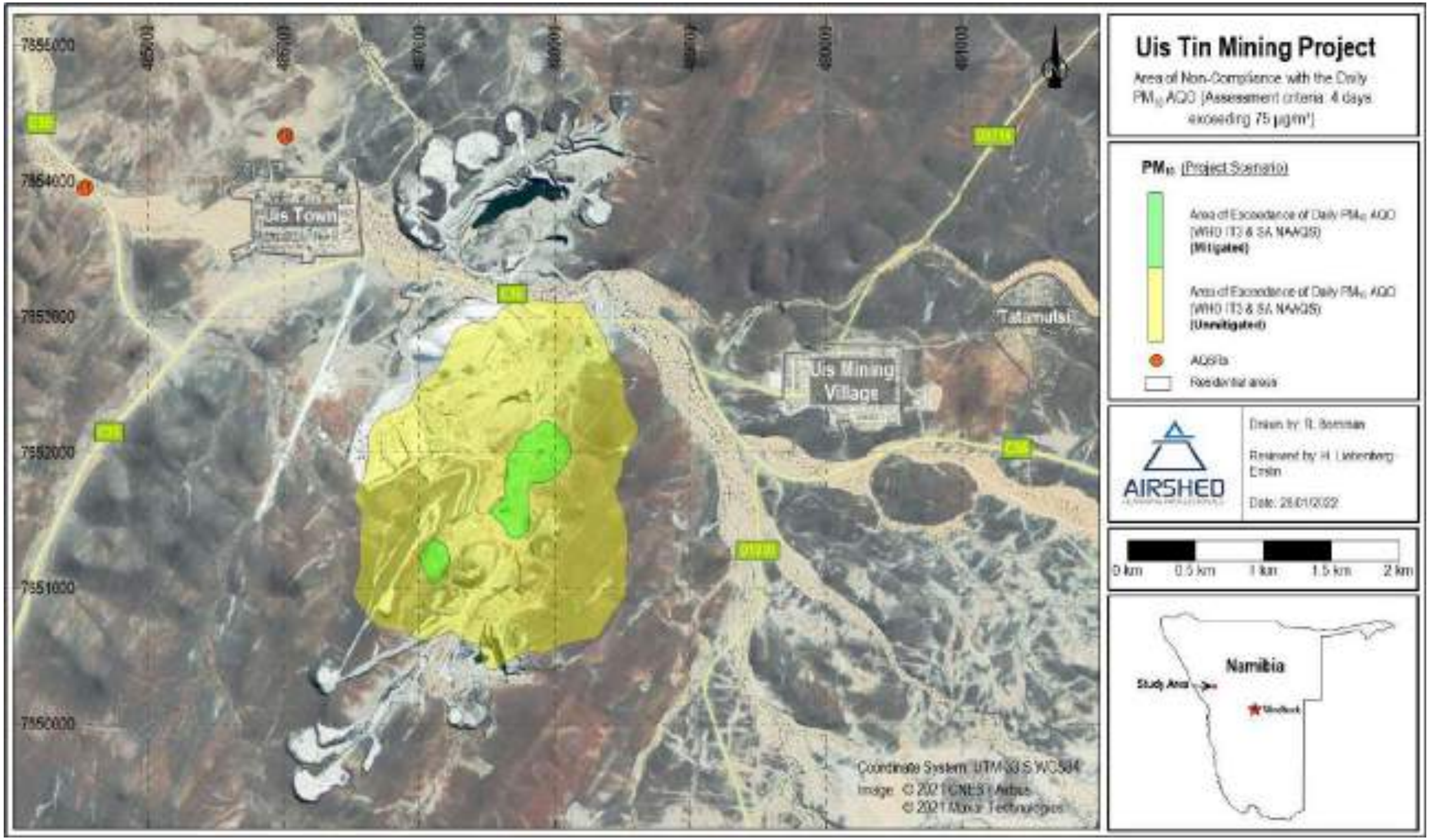

Figure 18: Area of non-compliance of <u>daily</u> PM_{10} AQO for unmitigated and mitigated Project operations

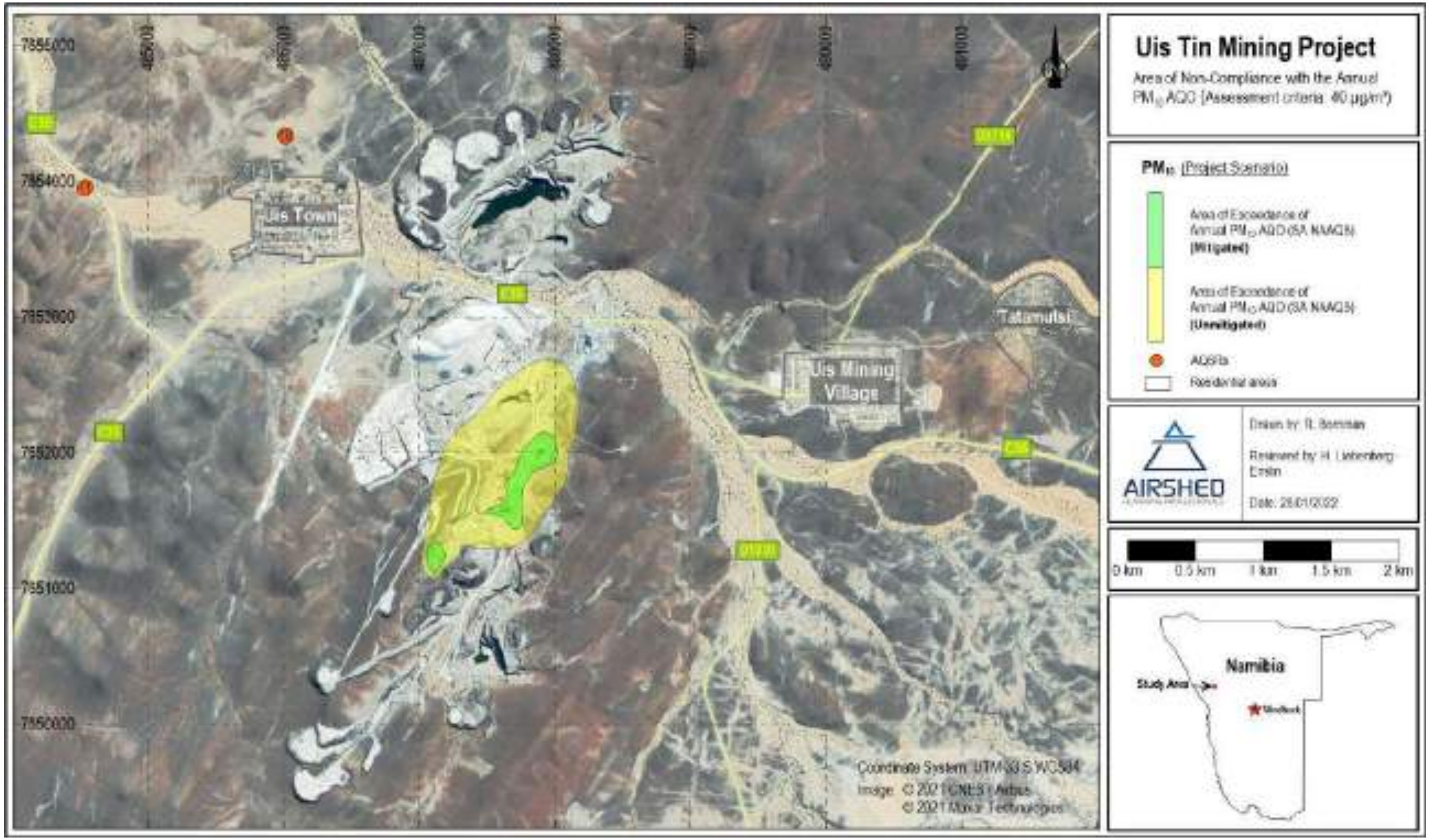

Figure 19: Area of non-compliance of annual PM_{10} AQO for unmitigated and mitigated Project operations

4.3.2 $PM_{2.5}$

4.3.2.1 Baseline Scenario

The simulated exceedances of highest daily and annual average $PM_{2.5}$ AQOs for unmitigated and mitigated Baseline operations are provided in Figure 20 and Figure 21 respectively, with the GLCs at the nearest AQSRs provided in Table 15.

$PM_{2.5}$ daily GLCs, for unmitigated activities, do not exceed the AQO (WHO IT-3) at any of the AQSRs but the footprint of exceedance extends ~300 m off-site. For mitigated activities, there are no exceedances at any of the AQSRs and impacts are limited to on-site areas. There are no exceedances of the annual $PM_{2.5}$ AQO, without and with mitigation in place.

4.3.2.2 Project Scenario

The simulated exceedances of highest daily and annual average $PM_{2.5}$ AQOs for unmitigated and mitigated Project operations are provided in Figure 22 and Figure 23 respectively, with the GLCs at the nearest AQSRs provided in Table 15.

For daily $PM_{2.5}$ the area of maximum unmitigated GLCs exceedance extends northwest from the Uis mining operations over a maximum distance of ~750 m, with no exceedances at any of the AQSRs. With mitigation in place there are no exceedances at any of the AQSRs and the impact is reduced to much smaller areas of exceedance, mainly on-site. Annual average $PM_{2.5}$ GLCs are low at all AQSRs.

Table 15: Simulated $PM_{2.5}$ ground level concentrations (in µg/m³) at selected AQSRs for BASELINE and PROJECT operations (non-compliance is highlighted)

AQSR	BASELINE						PROJECT					
	Unmitigated			Mitigated			Unmitigated			Mitigated		
	Annual Avg	Highest Day	FOE	Annual Avg	Highest Day	FOE	Annual Avg	Highest Day	FOE	Annual Avg	Highest Day	FOE
AQO	15 µg/m³	37.5 µg/m³	>4 days/year	15 µg/m³	37.5 µg/m³	>4 days/year	15 µg/m³	37.5 µg/m³	>4 days/year	15 µg/m³	37.5 µg/m³	>4 days/year
0	0.25	2.10	0	0.15	1.22	0	0.33	2.87	0	0.11	1.00	0
1	0.24	2.06	0	0.14	1.37	0	0.31	2.67	0	0.11	0.98	0
2	0.25	2.09	0	0.15	1.36	0	0.32	2.69	0	0.11	1.05	0
3	0.25	2.10	0	0.15	1.21	0	0.33	2.79	0	0.11	0.95	0
4	0.26	2.23	0	0.15	1.43	0	0.34	2.77	0	0.12	1.08	0
5	0.26	2.13	0	0.15	1.37	0	0.34	2.78	0	0.12	1.11	0
6	0.25	1.97	0	0.15	1.23	0	0.33	2.61	0	0.11	1.08	0
7	0.26	2.13	0	0.15	1.24	0	0.34	2.83	0	0.12	0.96	0
8	0.22	1.54	0	0.13	0.87	0	0.29	2.12	0	0.10	0.68	0
9	0.22	1.55	0	0.13	0.91	0	0.29	2.04	0	0.10	0.66	0
10	0.21	1.46	0	0.13	0.87	0	0.28	2.00	0	0.10	0.66	0
11	0.31	2.33	0	0.19	1.23	0	0.41	3.13	0	0.14	0.87	0
12	0.24	2.36	0	0.14	1.31	0	0.31	3.25	0	0.11	0.96	0
13	0.23	2.32	0	0.14	1.26	0	0.30	3.19	0	0.11	0.93	0
14	0.22	2.47	0	0.14	1.42	0	0.29	3.26	0	0.10	1.00	0
15	0.24	3.13	0	0.14	1.75	0	0.31	4.18	0	0.11	1.13	0
16	0.07	1.93	0	0.04	1.05	0	0.09	2.58	0	0.02	0.79	0
17	0.03	1.06	0	0.02	0.58	0	0.04	1.50	0	0.01	0.39	0
18	0.50	3.11	0	0.30	1.81	0	0.65	4.15	0	0.23	1.30	0
19	0.27	1.98	0	0.17	1.14	0	0.35	2.71	0	0.13	0.88	0
Uis Town	0.72	4.09	0	0.43	2.16	0	0.94	5.75	0	0.33	1.65	0
Uis Village	0.15	3.72	0	0.08	1.65	0	0.20	5.22	0	0.05	1.08	0
Tatamutsi	0.06	1.49	0	0.03	0.77	0	0.08	2.07	0	0.02	0.56	0

Notes:

(a) BASELINE: Mitigation includes 75% control efficiency (CE) on unpaved surface roads and 50% CE on unpaved in-pit roads (using water sprays), 50% CE on primary and secondary crushing and materials handling operations (using water sprays), >75% CE for tertiary and fines crushing and screening (wet process)

(b) PROJECT: Mitigation includes all control measures listed in (a), but with 99% CE on primary and secondary crushing operations.

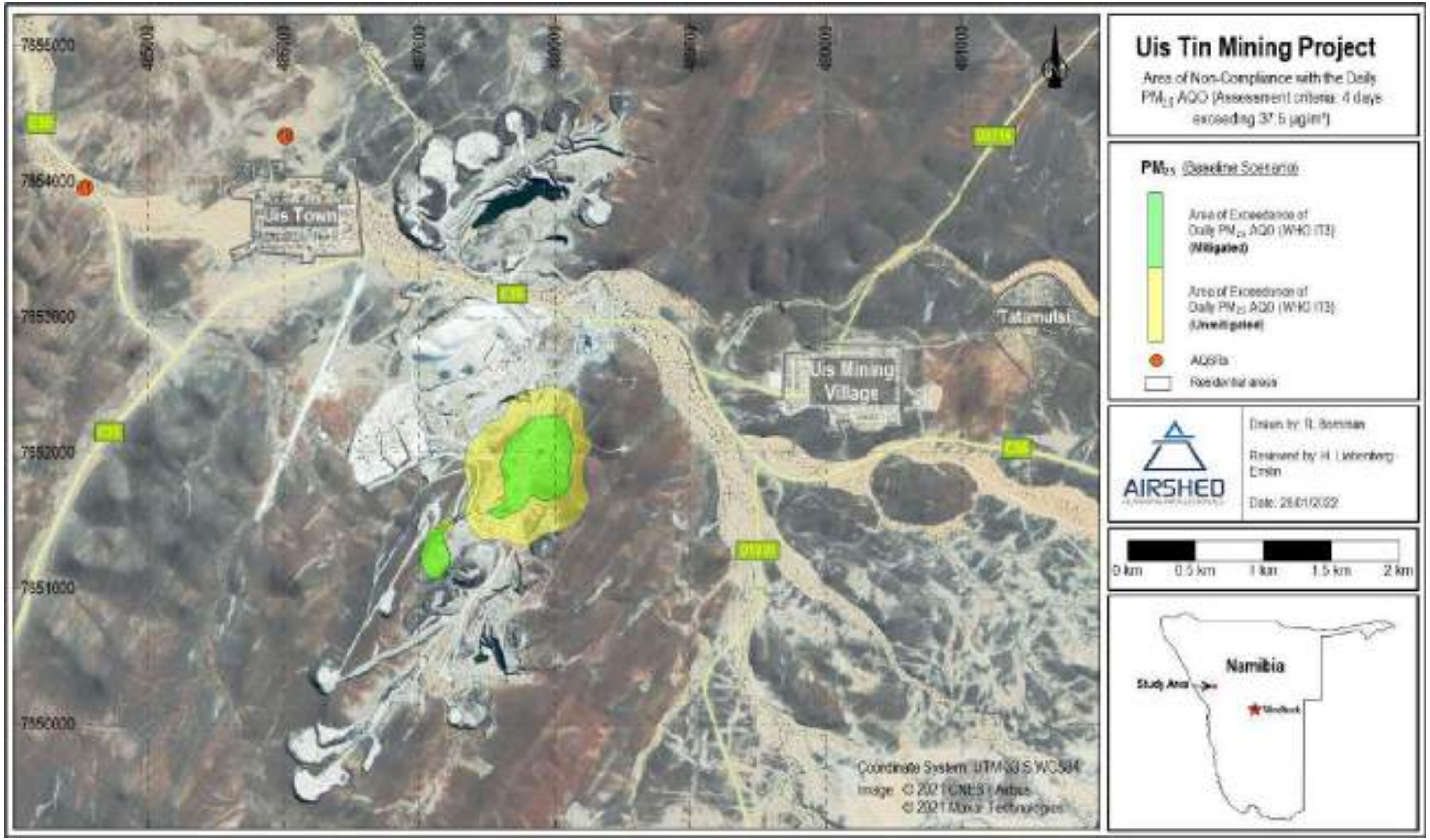

Figure 20: Area of non-compliance of <u>daily</u> $PM_{2.5}$ AQO for unmitigated and mitigated Baseline operations

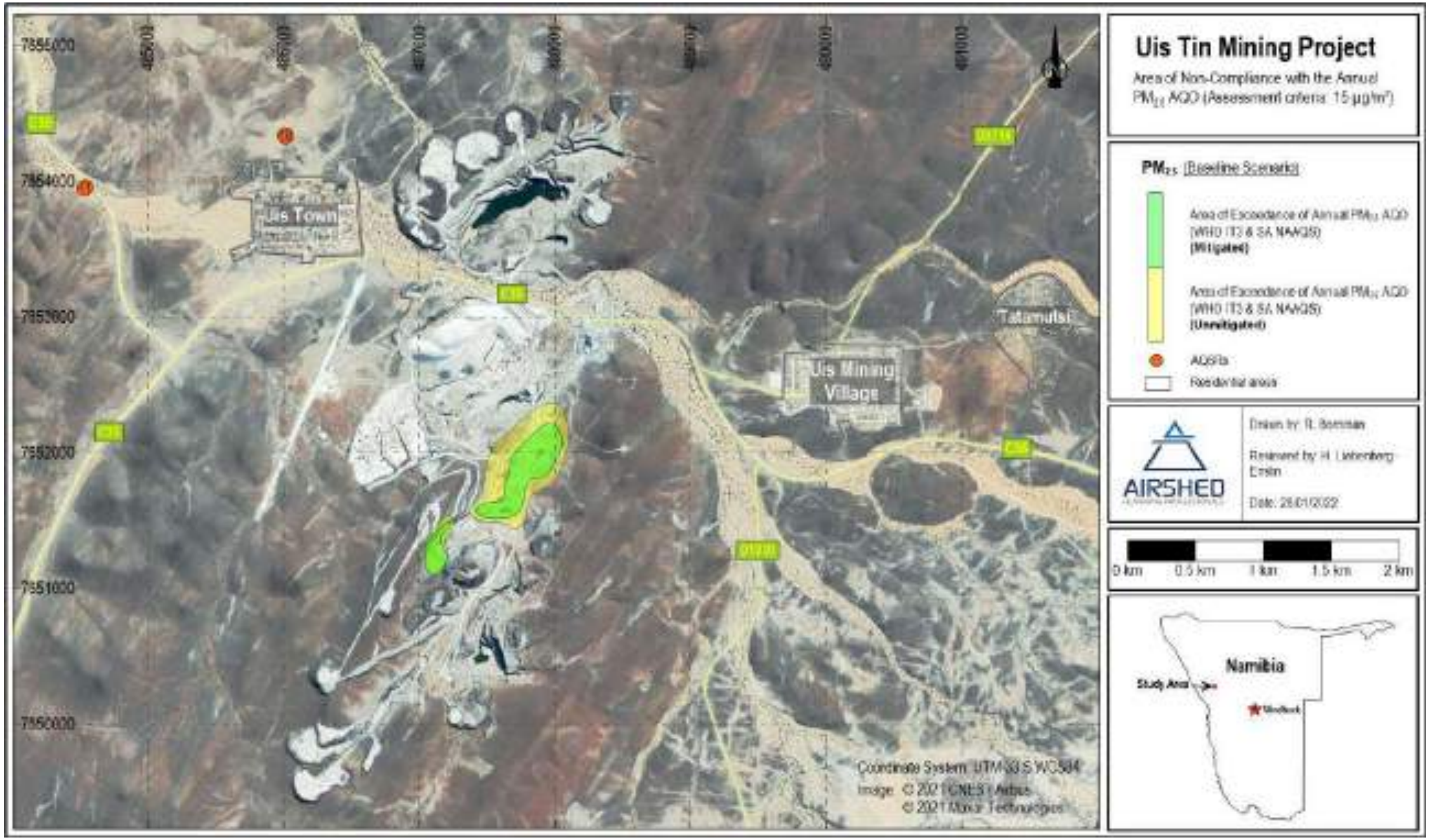

Figure 21: Area of non-compliance of annual $PM_{2.5}$ AQO for unmitigated and mitigated Baseline operations

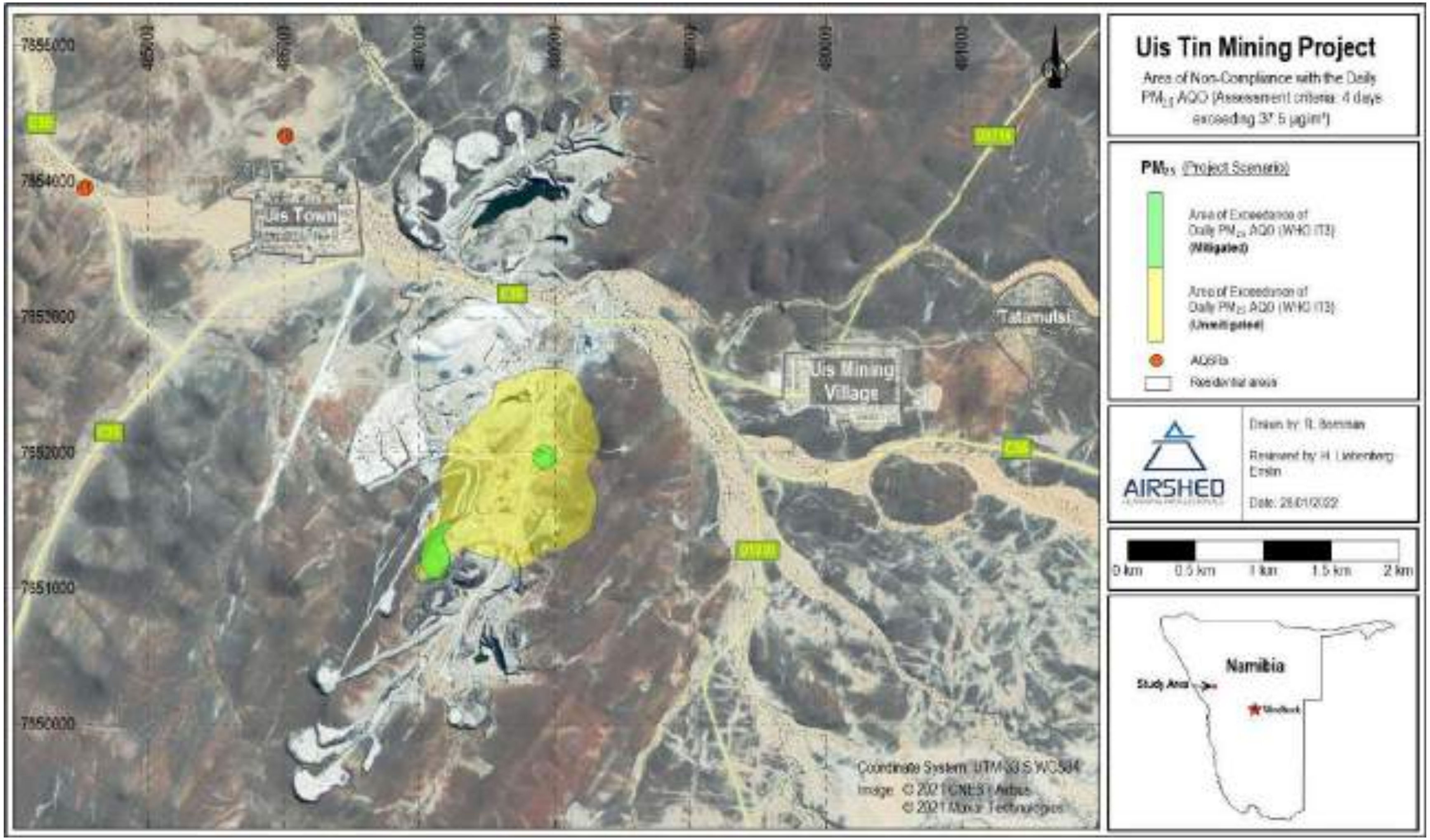

Figure 22: Area of non-compliance of daily $PM_{2.5}$ AQO for unmitigated and mitigated Project operations

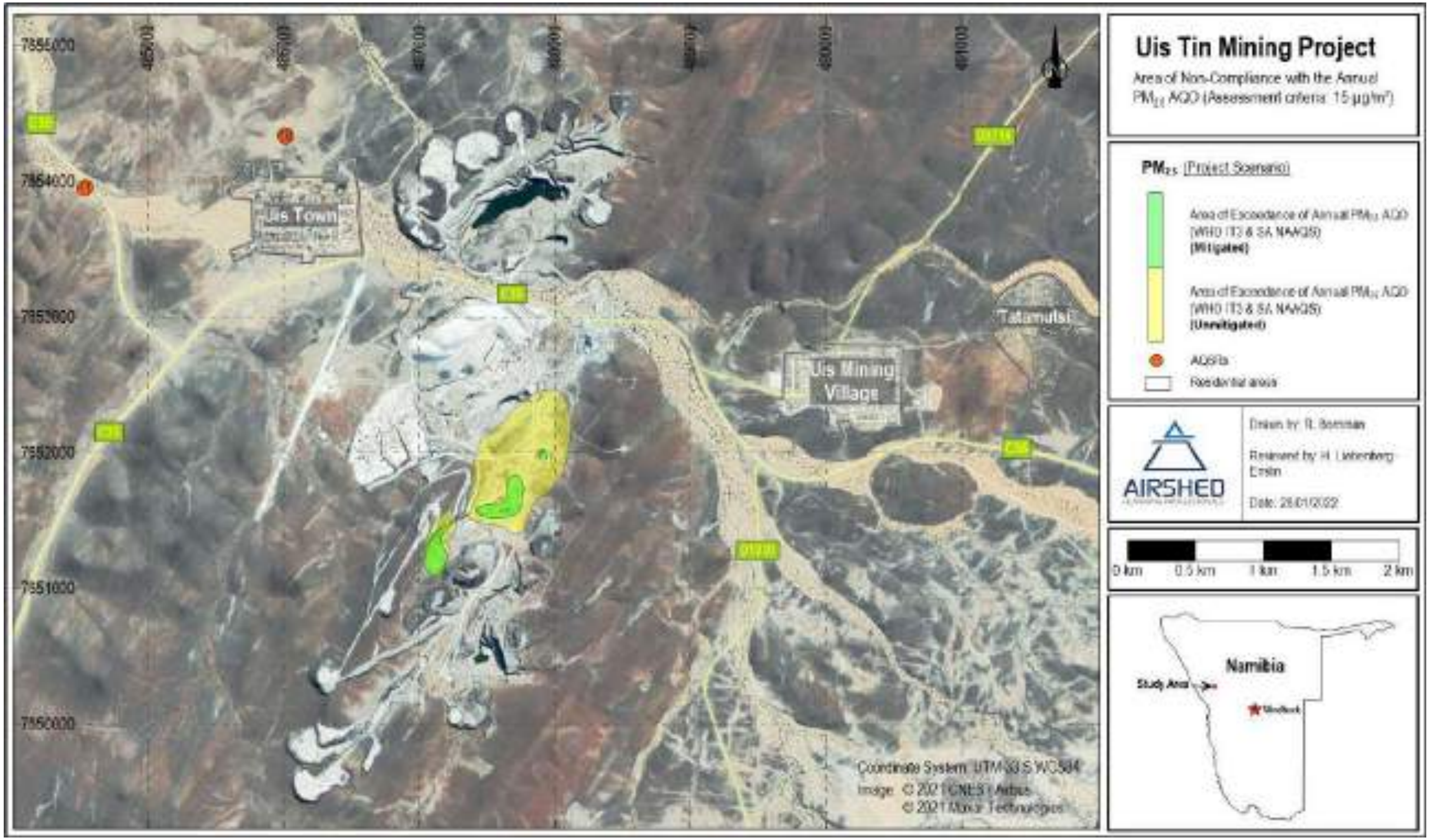

Figure 23: Area of non-compliance of annual $PM_{2.5}$ AQO for unmitigated and mitigated Project operations

4.3.3 Dustfall

The simulated daily dustfall rates for mitigated and unmitigated activities are provided in Figure 24 and Figure 25 respectively, with the values at each of the AQSRs provided in Table 16.

4.3.3.1 Baseline Scenario

Maximum daily dustfall rates, for both unmitigated and mitigated Baseline activities, are within the AQO (SA NDCR residential limit of 600 mg/m²/day) at all of the AQSRs (Table 16). Impacts are limited to on-site areas (Figure 24).

4.3.3.2 Project Scenario

Maximum daily dustfall rates, for both unmitigated and mitigated Project activities, are within the AQO (SA NDCR residential limit of 600 mg/m²/day) at all of the AQSRs (Table 16). Similar to the Baseline scenario, the footprint area of exceedance of the AQO is limited on-site (Figure 25).

Table 16: Simulated dustfall rates (in mg/m²/day) at selected AQSRs for BASELINE and PROJECT operations (non-compliance is highlighted)

AQSR	BASELINE		PROJECT	
	Unmitigated	Mitigated	Unmitigated	Mitigated
	Highest 30-day average	Highest 30-day average	Highest 30-day average	Highest 30-day average
AQO	600 mg/m²/day	600 mg/m²/day	600 mg/m²/day	600 mg/m²/day
0	0.44	0.15	0.63	0.10
1	0.38	0.13	0.55	0.09
2	0.42	0.14	0.60	0.10
3	0.43	0.15	0.62	0.10
4	0.44	0.15	0.64	0.10
5	0.44	0.15	0.63	0.10
6	0.41	0.14	0.59	0.09
7	0.44	0.15	0.64	0.10
8	0.57	0.20	0.83	0.13
9	0.58	0.20	0.84	0.13
10	0.54	0.19	0.79	0.12
11	1.01	0.35	1.46	0.24
12	0.69	0.28	0.98	0.21
13	0.65	0.26	0.92	0.20
14	0.83	0.33	1.17	0.26
15	1.02	0.41	1.44	0.32
16	0.36	0.13	0.51	0.10
17	0.23	0.09	0.32	0.07
18	1.72	0.61	2.50	0.45
19	0.69	0.24	1.01	0.16
Uis Town	3.19	1.14	4.64	0.90
Uis Village	1.30	0.54	1.79	0.42
Tatamutsi	0.36	0.14	0.50	0.11

Notes:

(a) BASELINE: Mitigation includes 75% control efficiency (CE) on unpaved surface roads and 50% CE on unpaved in-pit roads (using water sprays), 50% CE on primary and secondary crushing and materials handling operations (using water sprays), >75% CE for tertiary and fines crushing and screening (wet process).

(b) PROJECT: Mitigation includes all control measures listed in (a), but with 99% CE on primary and secondary crushing operations.

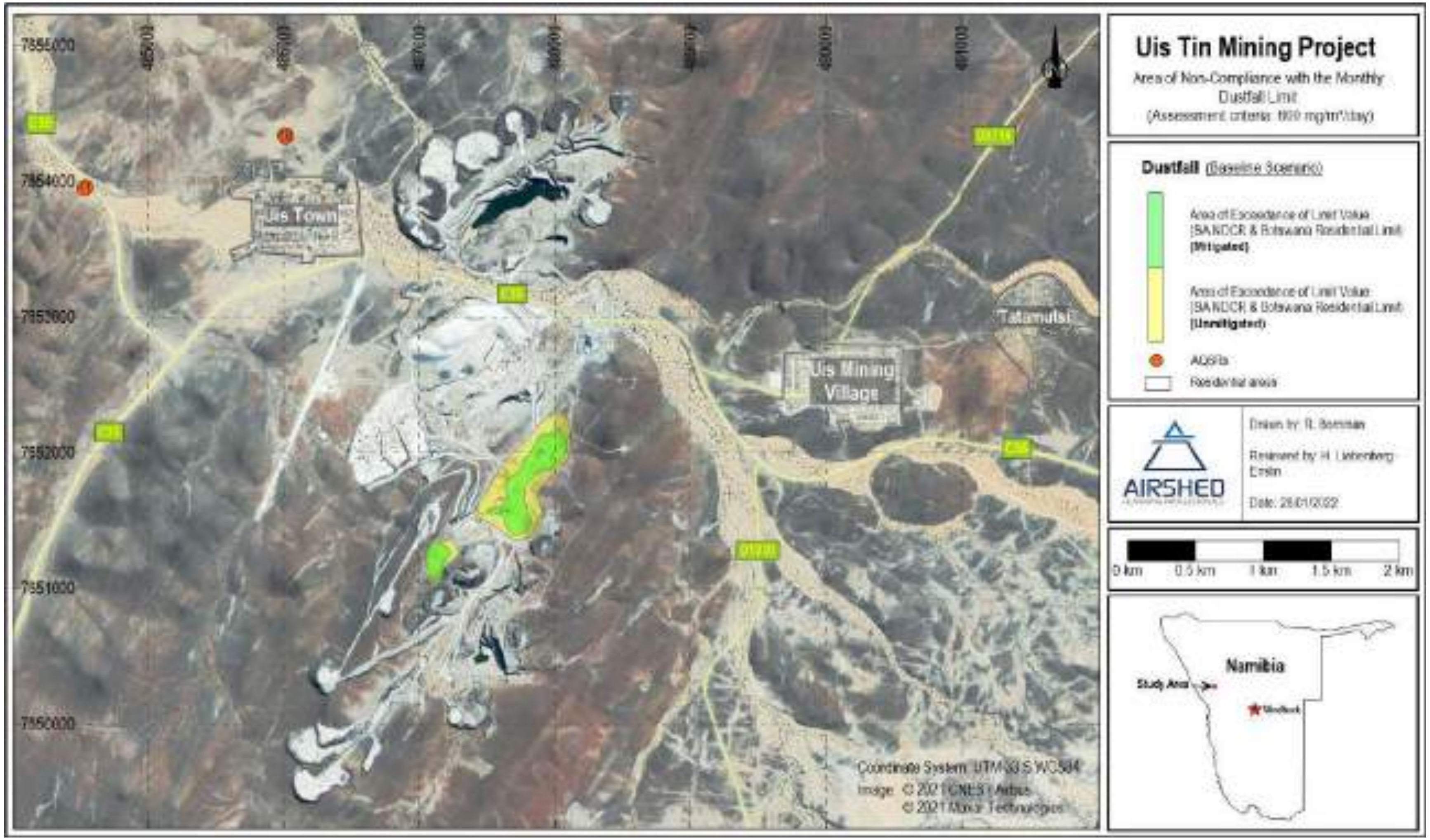

Figure 24: Area of non-compliance of dustfall limit values for unmitigated and mitigated Baseline operations

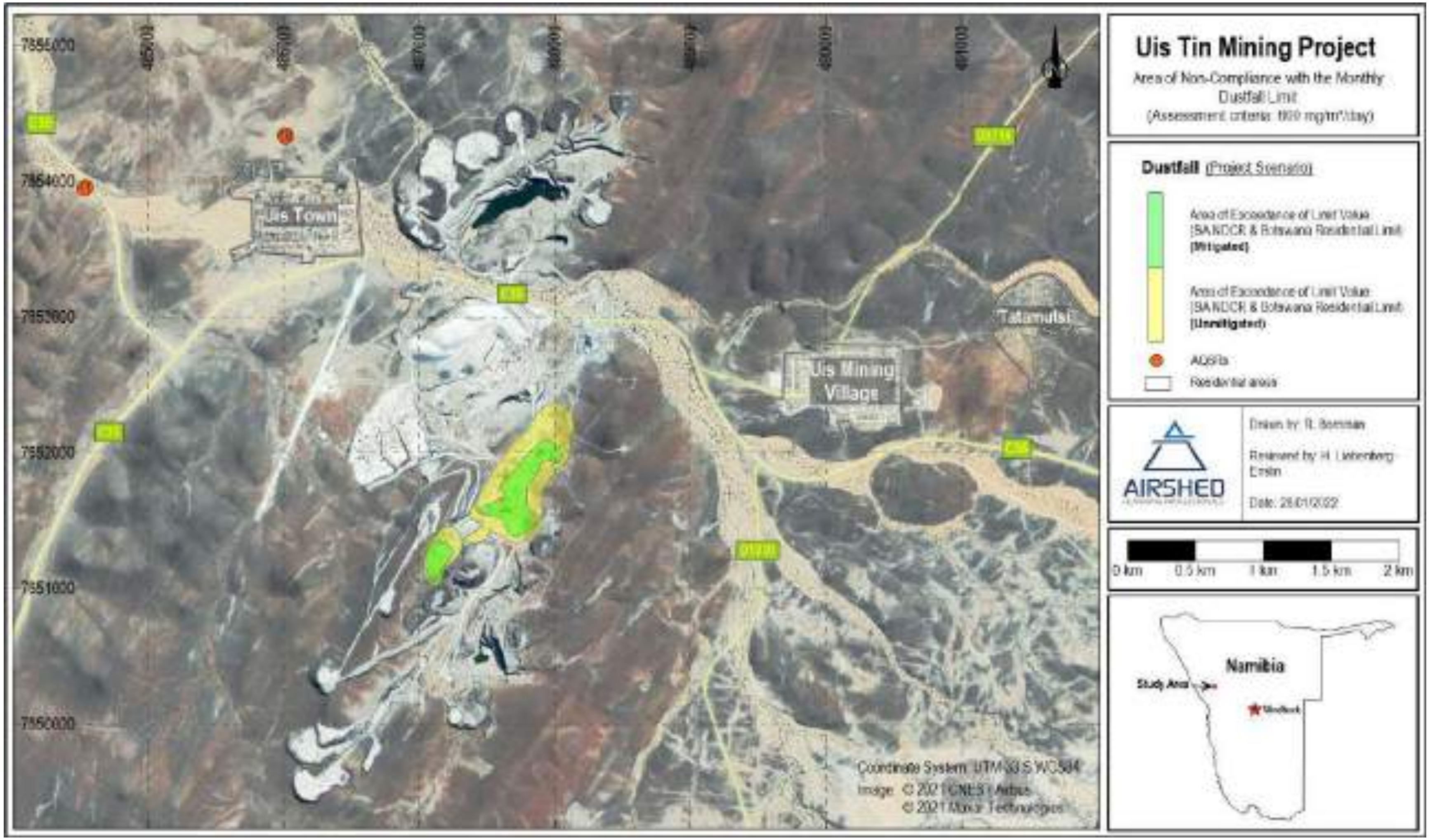

Figure 25: Area of non-compliance of dustfall limit values for unmitigated and mitigated Project operations

5 ESIA AMENDMENT – IMPACT OF PROPOSED PROJECT ON THE RECEIVING ENVIRONMENT

5.1 Project Description

The ESIA for the Uis Tin Mine is to be amended to include material changes they intend to add to their existing operations. A bulk sampling, and ore sorting and testing facility (from now on referred to as the Petalite Beneficiation Plant) will be constructed to extract the lithium-bearing ore. This will then be fed to a petalite beneficiation plant where the lithium will be extracted and processed. The waste from these two processes will be captured and handled in what the mine terms a waste neutralisation facility.

The purpose of the bulk sample processing facility is to undertake metallurgical test work on the material from the existing mine pits, as well as from external areas where exploration work is being undertaken to assess the process required to extract minerals from the ore(s). The proposed location of the facility is shown in Figure 26. Extraction of minerals such as tin, tungsten, tantalum, lithium, copper, silver and gold will be assessed. The facility is a testing facility, which will not run continuously. Testing campaigns will run for a maximum of 100 hours (approximately 4 days) after which the plant will be stopped for cleaning to prevent contamination between sampling campaigns. It is expected that one testing campaign will run per month, with a maximum of two. The facility will comprise a ROM pad, the metallurgical support facility (MSF), the bulk splitting area and the dense media separation (DMS) and flotation processing facilities (Figure 27).

Waste neutralisation will be part of the DMS and flotation circuit and is probably going to take place prior to the filter press (or will occur within the filter press). This means that both the water and discard (filter cakes) will be neutralised.

The mining fleet will not be impacted by this testing facility. Earth moving equipment (i.e., ~ 1 x front-end loader and 1 x bobcat) will be used to move material within the testing facility during the bulk sampling and testing campaigns. External traffic for the bulk sampling and testing campaigns include: 1 x truck delivering hydrogen fluoride (HF) and 1 x truck delivering sulfuric acid (H_2SO_4). This will be separate to the current mining fleet and will be trucks specifically assigned/contracted for this process.

The activities that could potentially give rise to atmospheric emissions are discussed in Section 5.2. The throughputs that were used to calculate emissions for the Incremental Project scenario are provided in Table 17.

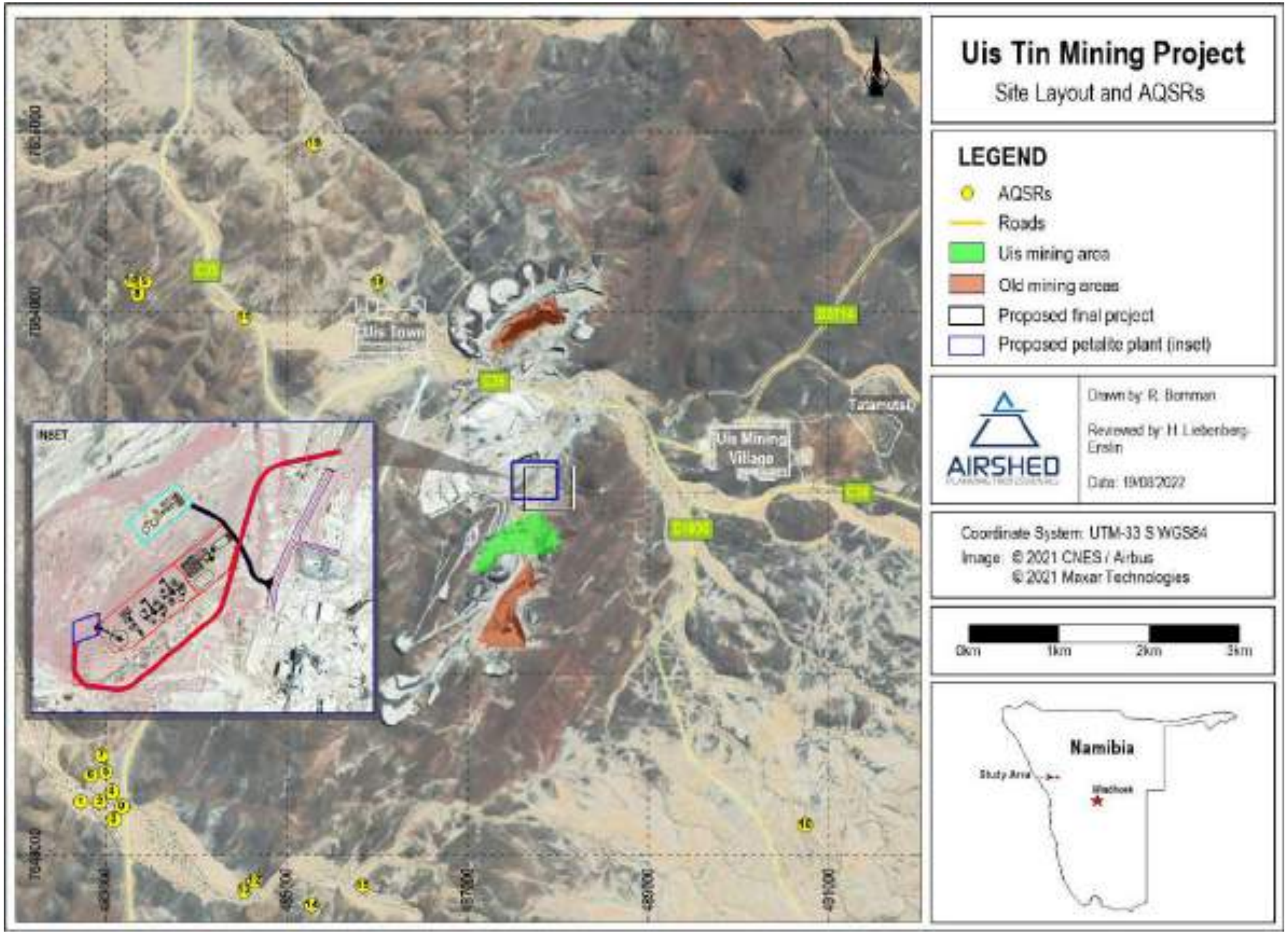

Figure 26: Proposed Petalite Beneficiation Plant location (relative to Uis Mining Project)

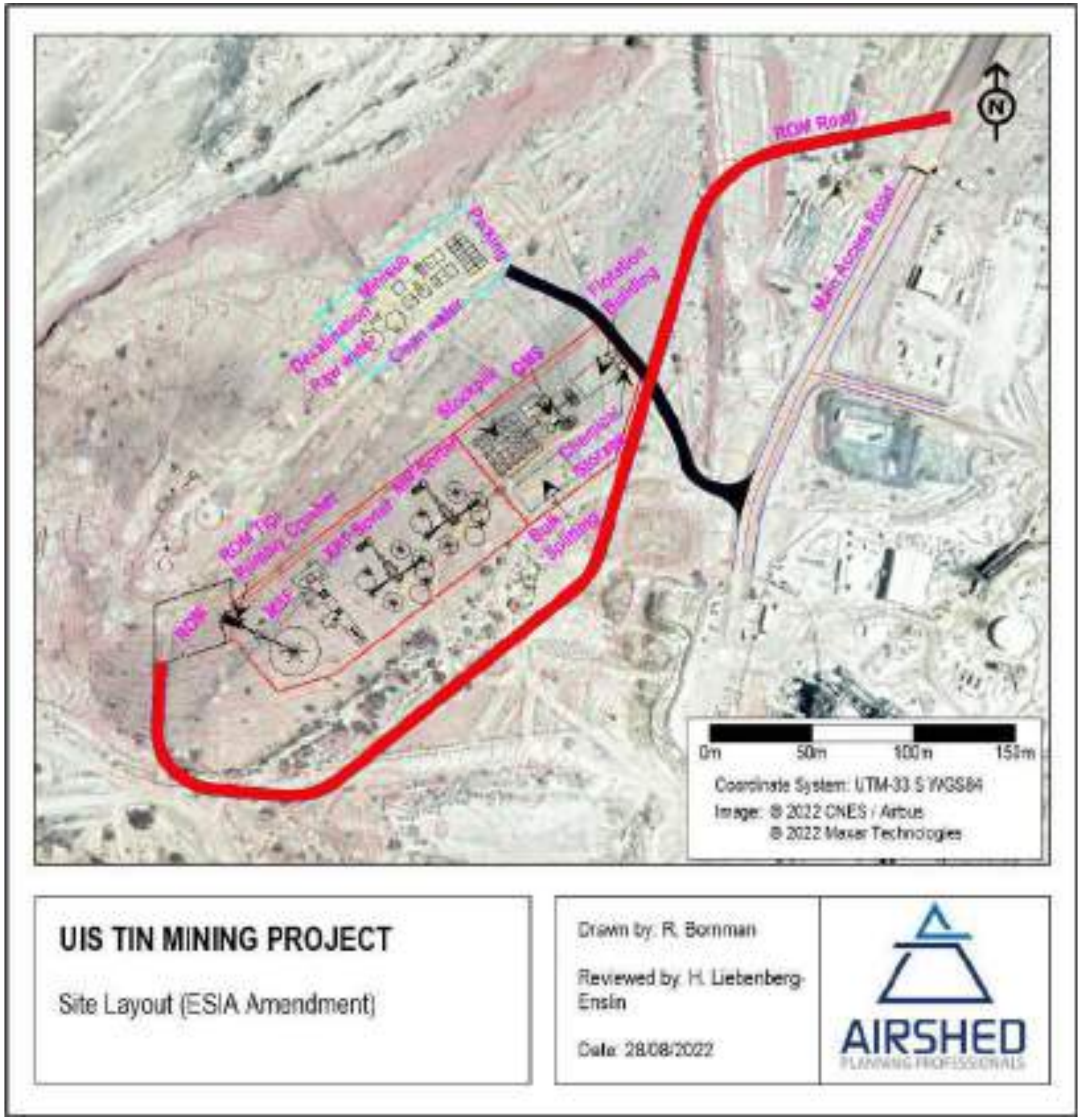

Figure 27: Proposed Petalite Beneficiation Plant layout

5.2 Atmospheric Emissions

The process flow diagram is shown in Figure 28. The proposed operations that may cause atmospheric emissions include:

- materials handling
- crushing
- drying and classification
- unpaved roads, and
- wind erosion.

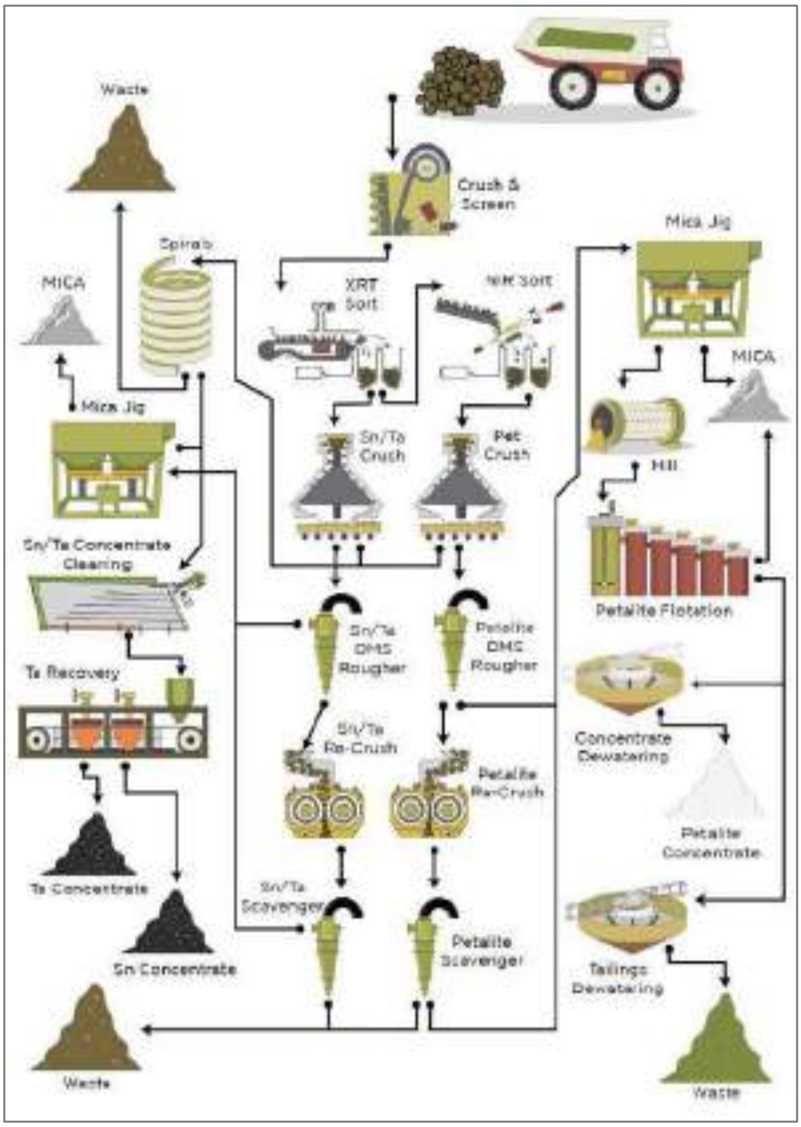

Figure 28: Flow diagram for the proposed Petalite Beneficiation Plant project

5.2.1 Emissions Inventory

Two operational scenarios were assessed, namely the incremental and cumulative Petalite Beneficiation Plant scenarios, each with an unmitigated and mitigated sub-scenario.

Operational hours were provided as continuous for DMS operations and daytime (assumed to be 10 hours) for all other activities. The throughputs that were used in the calculation of emissions are given in Table 17. Emission equations from Table 9 were used for materials handling[4], crushing[5] and unpaved roads[6]. Emission equations for drying and classification and wind erosion[7] are provided in Table 18. Summaries of particulate emissions for routine operations due to the Incremental and Cumulative Project scenarios are provided in Table 19 and source group contributions to total $PM_{2.5}$, PM_{10} and TSP emissions for the Incremental Project scenario are shown in Figure 29 and Figure 30 for unmitigated and design mitigated activities respectively.

Table 17: Throughputs used in the emissions inventory (in tph and tpm)

	Throughput		Comment
	tph (max)	tpm	
ROM	5.00	2000	Maximum 5 tph (client info)
HF	0.02	5	Client info
H_2SO_4	0.01	3	Client info
Product (Petalite)	1.75	700	Client info (35%)
Product (Sn)	0.15	60	Assume same as Mica
Product (Ta)	0.15	60	Assume same as Mica
Product (Mica)	0.15	60	Client info (3%)
Tailings	51.78	932	Client info
Waste	10.44	188	Calculated

[4] Materials handling includes offloading and loading ROM ore at feed pad, tip to ROM crushed ore stockpile, transfer to XRT and NRI sorters, tipping at XRT and NRI stockpiles, tipping at re-crushed ore stockpiles, offloading and loading of HF and H_2SO_4, and loading of product stockpiles.
[5] Primary crushing was assumed to take place at a rate of 5 tph. Secondary cone crushing of Sn/Ta and petalite was assumed to take place at a rate of 1.5 tph and 3.5 tph respectively. Ore was assumed to be low moisture ore.
[6] Unpaved roads include the main access road from the C36, the ROM road and the road to the parking space and office buildings. The load capacity of the vehicle transporting ROM was assumed as 20 tonnes, and the vehicle transporting chemicals was assumed to have 8 tonne capacity.
[7] Since no particle size distributions for the various stockpile materials were available, a general emission equation was used to estimate emissions due to wind erosion and applied in an hourly file for hours where the wind speed exceeds 5.4 m/s.

Table 18: Emission equations used to quantify the routine emissions from the proposed Petalite Beneficiation Plant

<table>
<tr><th>Activity</th><th>Emission Equation</th><th>Source</th><th>Information assumed/provided</th></tr>
<tr><td>Drying and Classifying</td><td>
<table>
<tr><td></td><td colspan="3">$E_{(Uncontrolled)}$</td><td colspan="3">$E_{(Controlled)}$</td></tr>
<tr><td></td><td>$PM_{2.5}$</td><td>PM_{10}</td><td>TSP</td><td>$PM_{2.5}$</td><td>PM_{10}</td><td>TSP</td></tr>
<tr><td>Flash drying</td><td>0.05</td><td>0.087</td><td>0.160</td><td>0.0042</td><td>0.0073</td><td>0.0134</td></tr>
<tr><td>Classifying</td><td>0.024</td><td>0.062</td><td>0.133</td><td>0.0020</td><td>0.0052</td><td>0.0112</td></tr>
<tr><td>Product storage</td><td>0.007</td><td>0.020</td><td>0.134</td><td>0.0003</td><td>0.0008</td><td>0.0055</td></tr>
</table>
Where,
E = particulate emission factor drying, classifying and product storage in kg/ton</td><td>US-EPA AP42
Table 11.19.2-3</td><td>Drying and classifying were modelled at the DMS and bulk splitting areas and product storage at the product stockpile.
Mitigation measures include fabric filter control for flash drying, classifying and product storage activities.</td></tr>
<tr><td>Wind Erosion</td><td>$$E_{TSP} = 0.4 \frac{kg}{ha} / \text{hr}$$
$$E_{PM_{10}} = 0.2 \frac{kg}{ha} / \text{hr}$$
Where,
E = particulate emission factor for windblown dust from storage piles in kilogram per hectare per hour.</td><td>NPi Section: Mining</td><td>The areas of the various stockpiles were on-screen digitised from the layout as follows:
<table>
<tr><th></th><th>Hectares (ha)</th></tr>
<tr><td>ROM feed pad:</td><td>0.12</td></tr>
<tr><td>Crushed ROM SP (Sn/Ta):</td><td>0.06</td></tr>
<tr><td>Crushed ROM SP (petalite):</td><td>0.003</td></tr>
<tr><td>Petalite product SP:</td><td>0.06</td></tr>
<tr><td>Sn/Ta concentrate SP:</td><td>0.003</td></tr>
<tr><td>Mica SP:</td><td>0.003</td></tr>
</table></td></tr>
</table>

Table 19: Calculated emission rates due to unmitigated and mitigated activities for the incremental and cumulative Petalite Beneficiation Plant scenarios respectively

Description	Incremental Project Scenario						Cumulative Project Scenario					
	Unmitigated			Mitigated			Unmitigated			Mitigated		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
In-pit (including drilling)	–	–	–	–	–	–	52.76	89.71	233.38	50.62	69.1	162.84
Blasting	–	–	–	–	–	–	0.06	1.04	24.4	0.06	1.04	24.4
Materials handling	0.04	0.28	0.58	0.02	0.14	0.29	1.36	9.02	19.05	0.56	3.69	7.8
Crushing and screening	0.91	1.83	25.55	0.46	0.91	12.78	26.18	113.84	821.95	0.89	4.65	25.58
Drying and Classifying	1.44	2.97	7.32	0.12	0.24	0.53	1.44	2.97	7.32	0.12	0.24	0.53
Unpaved roads	0.33	3.33	11.72	0.08	0.83	2.93	13.48	134.79	471.71	3.37	33.69	117.93
Wind erosion	0.02	0.15	0.30	0.02	0.15	0.30	3.61	13.12	50.21	3.61	13.12	50.21
Total	**3**	**9**	**45**	**1**	**2**	**17**	**99**	**364**	**1628**	**59**	**126**	**390**

Notes:

(a) Incremental Project: Mitigation includes 75% control efficiency (CE) on unpaved surface roads (using water sprays), 50% CE on primary and secondary crushing and materials handling operations (using water sprays), >90% CE for drying, classifying and product storage (using fabric filters)

(b) Cumulative Project: Mitigation includes all control measures listed in (a), but with additional measures listed under Table 13 (PROJECT scenario).

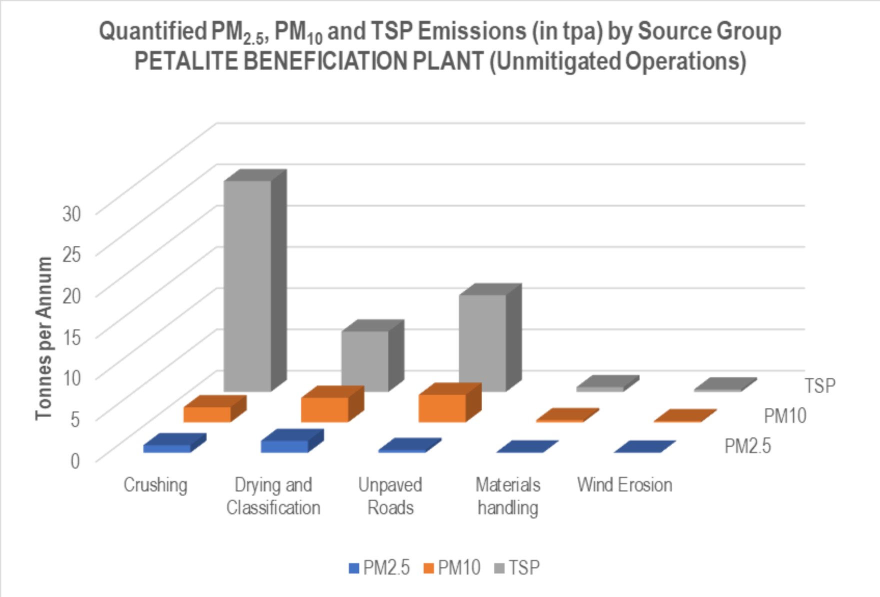

Figure 29: Contribution of particulate emissions per source group (unmitigated)

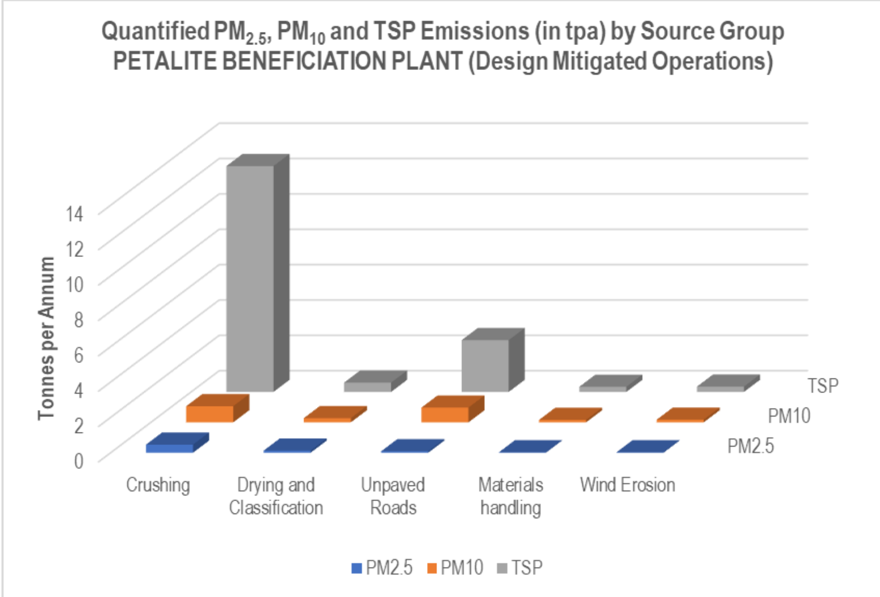

Figure 30: Contribution of particulate emissions per source group (design mitigated)

5.3 Atmospheric Dispersion Modelling

The impact of proposed operations on the atmospheric environment was determined through the simulation of ambient pollutant concentrations using the ADMS model.

The dispersion of pollutants was modelled for an area covering 10 km by 10 km with the grid matrix divided with a resolution of 100 m. The surrounding receptors were included as discrete receptors. Topography was included in dispersion simulations.

5.4 Dispersion Modelling Results

5.4.1 Incremental Petalite Beneficiation Plant Scenario

The isopleth plots in this section reflect simulated PM_{10} daily concentrations due to unmitigated and mitigated activities (Figure 31 and Figure 32), simulated $PM_{2.5}$ daily concentrations due to unmitigated and mitigated activities (Figure 33 and Figure 34) and simulated dust fallout rates due to unmitigated and mitigated activities (Figure 35 and Figure 36). The simulated incremental GLCs for $PM_{2.5}$ and PM_{10} (in µg/m³) and maximum daily dustfall rates (in mg/m²/day) are provided in Table 20.

From Figure 31 and Figure 33 PM_{10} and $PM_{2.5}$ daily GLCs, for unmitigated activities, result in exceedances of the 24-hour air quality objective (AQO) over a maximum distance of ~90 m from on-site activities, and from Figure 35 the footprint of exceedance of maximum daily dustfall rates exceed the AQO within 125 m from the facility's activities, but with no exceedances at any of the AQSRs. For mitigated activities, PM_{10} and $PM_{2.5}$ daily GLCs are within the AQO both on-site and at AQSRs, whereas dustfall rates exceeding the AQO are limited to an area surrounding the primary crusher. From Table 20 it may be seen that simulated values for PM_{10}, $PM_{2.5}$ and maximum daily dustfall rates are negligibly small.

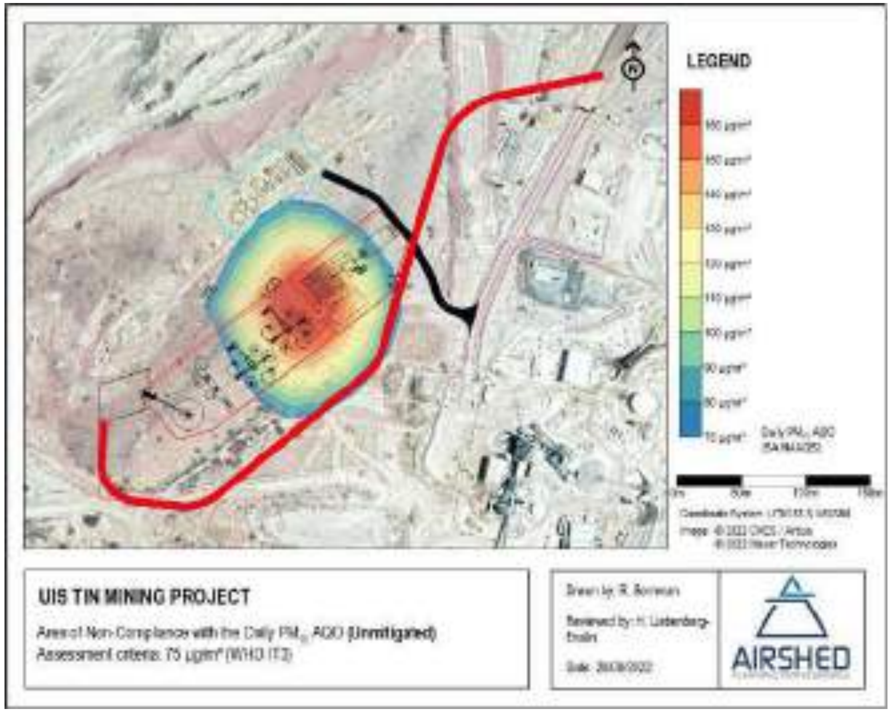

Figure 31: Area of non-compliance of daily PM_{10} AQO for unmitigated incremental operations

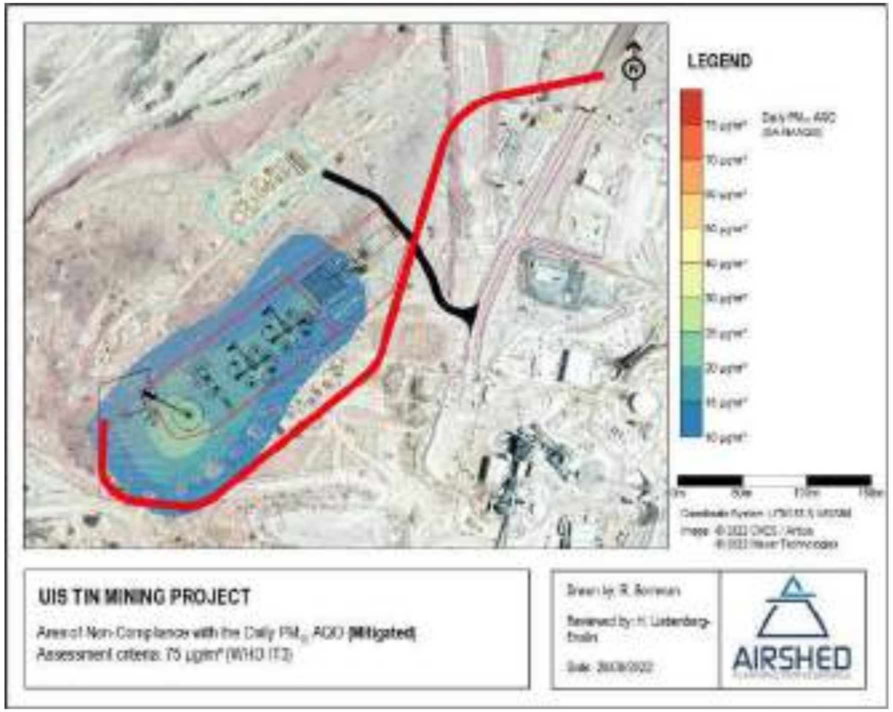

Figure 32: Area of non-compliance of daily PM_{10} AQO for mitigated incremental operations

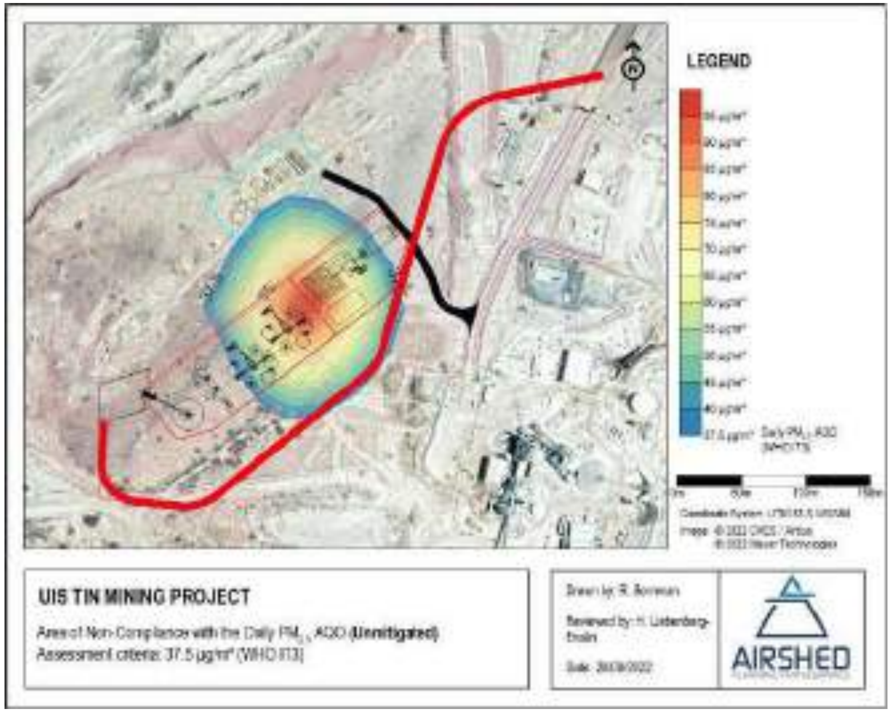

Figure 33: Area of non-compliance of daily $PM_{2.5}$ AQO for unmitigated incremental operations

Figure 34: Area of non-compliance of daily $PM_{2.5}$ AQO for mitigated incremental operations

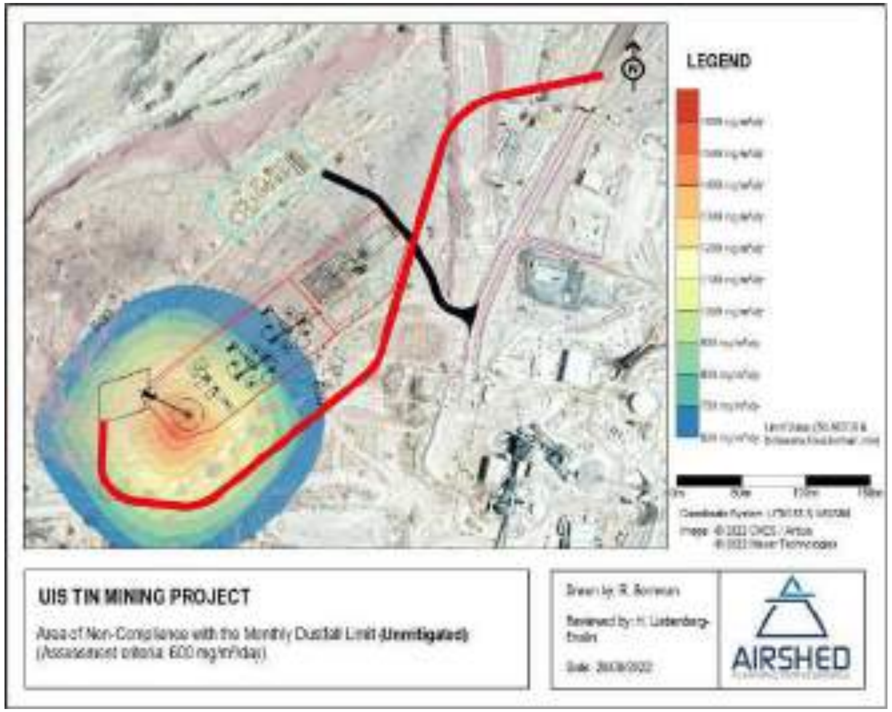

Figure 35: Area of non-compliance of dustfall limit values for unmitigated incremental operations

Figure 36: Area of non-compliance of dustfall limit values for mitigated incremental operations

Table 20: Simulated PM_{10} and $PM_{2.5}$ ground level concentrations (in µg/m³) and maximum daily dustfall rates (in mg/m²/day) at selected AQSRs for incremental Petalite Beneficiation Plant operations

AQSR	Petalite Beneficiation Plant (Incremental)					
	Unmitigated			Mitigated		
	$PM_{2.5}$ Highest Day	PM_{10} Highest Day	Dust Fallout Highest Monthly	$PM_{2.5}$ Highest Day	PM_{10} Highest Day	Dust Fallout Highest Monthly
AQO	37.5 µg/m³	75 µg/m³	600 mg/m2/day	37.5 µg/m³	75 µg/m³	600 mg/m2/day
0	0.05	0.10	0.02	0.01	0.02	0.01
1	0.05	0.09	0.01	0.01	0.02	0.00
2	0.05	0.10	0.02	0.01	0.02	0.01
3	0.05	0.09	0.02	0.01	0.02	0.01
4	0.05	0.10	0.02	0.01	0.02	0.01
5	0.05	0.10	0.01	0.01	0.02	0.01
6	0.05	0.09	0.01	0.01	0.02	0.00
7	0.05	0.09	0.01	0.01	0.02	0.00
8	0.04	0.08	0.01	0.00	0.01	0.00
9	0.04	0.08	0.01	0.00	0.01	0.00
10	0.04	0.08	0.01	0.00	0.01	0.00
11	0.06	0.12	0.02	0.01	0.01	0.00
12	0.06	0.11	0.08	0.01	0.02	0.03
13	0.05	0.10	0.07	0.01	0.02	0.03
14	0.06	0.13	0.10	0.01	0.02	0.04
15	0.09	0.16	0.12	0.01	0.03	0.05
16	0.05	0.09	0.03	0.01	0.01	0.01
17	0.03	0.05	0.02	0.00	0.01	0.01
18	0.11	0.20	0.03	0.01	0.02	0.01
19	0.05	0.09	0.01	0.00	0.01	0.00
Uis Town	0.15	0.28	0.08	0.01	0.02	0.03
Uis Village	0.11	0.20	0.05	0.01	0.02	0.01
Tatamutsi	0.04	0.07	0.03	0.00	0.01	0.01

Notes:

INCREMENTAL PROJECT: 50% CE on primary and secondary crushing and materials handling operations (using water sprays), 75% CE on unpaved surface roads, >90% CE on drying, classifying and product storage through fabric filter control.

5.4.2 Cumulative Project Scenario

Simulated PM_{10} exceedances of highest daily AQO due to cumulative unmitigated and mitigated activities are shown in Figure 37. Similarly, simulated $PM_{2.5}$ exceedances of highest daily AQO due to cumulative unmitigated and mitigated activities are shown in Figure 38 and simulated daily dustfall rates due to cumulative mitigated and unmitigated activities are depicted in Figure 39. The simulated cumulative GLCs for $PM_{2.5}$ and PM_{10} (in µg/m³) and maximum daily dustfall rates (in mg/m²/day) are provided in Table 21.

A comparison between isopleth plots in this section and Sections 4.3.1.2, 4.3.2.2 and 4.3.3.2 reveals that the cumulative plots including the Petalite Beneficiation Plant are not significantly different from those for the Project Scenario in Section 4.3. The numerical results in Table 14, Table 15 and Table 16 are also not significantly different from those in Table 21. It may therefore be concluded that the conclusions from this report would not change as a result of the Petalite Beneficiation Plant.

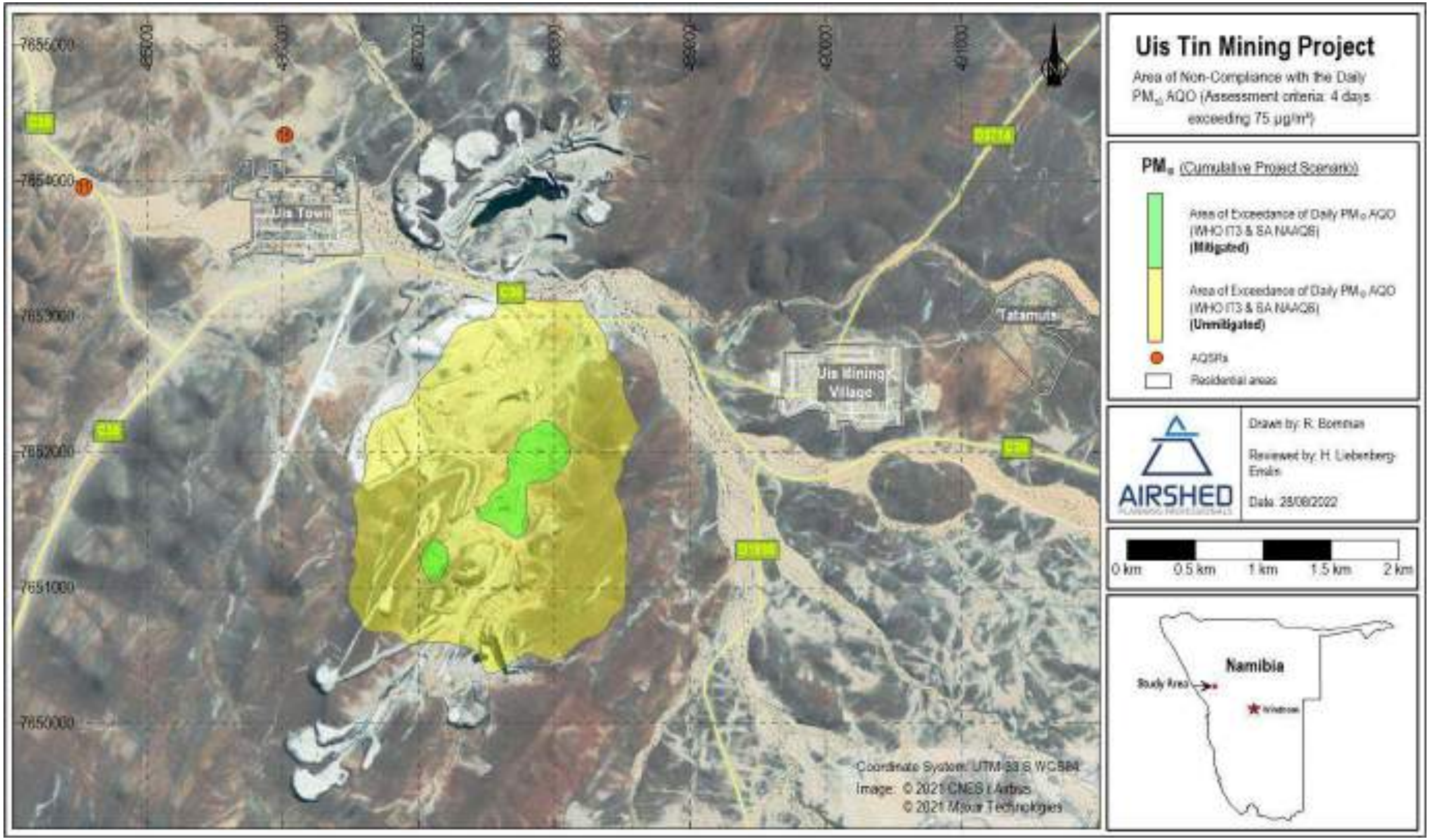

Figure 37: Area of non-compliance of daily PM_{10} AQO for unmitigated and mitigated cumulative Project operations

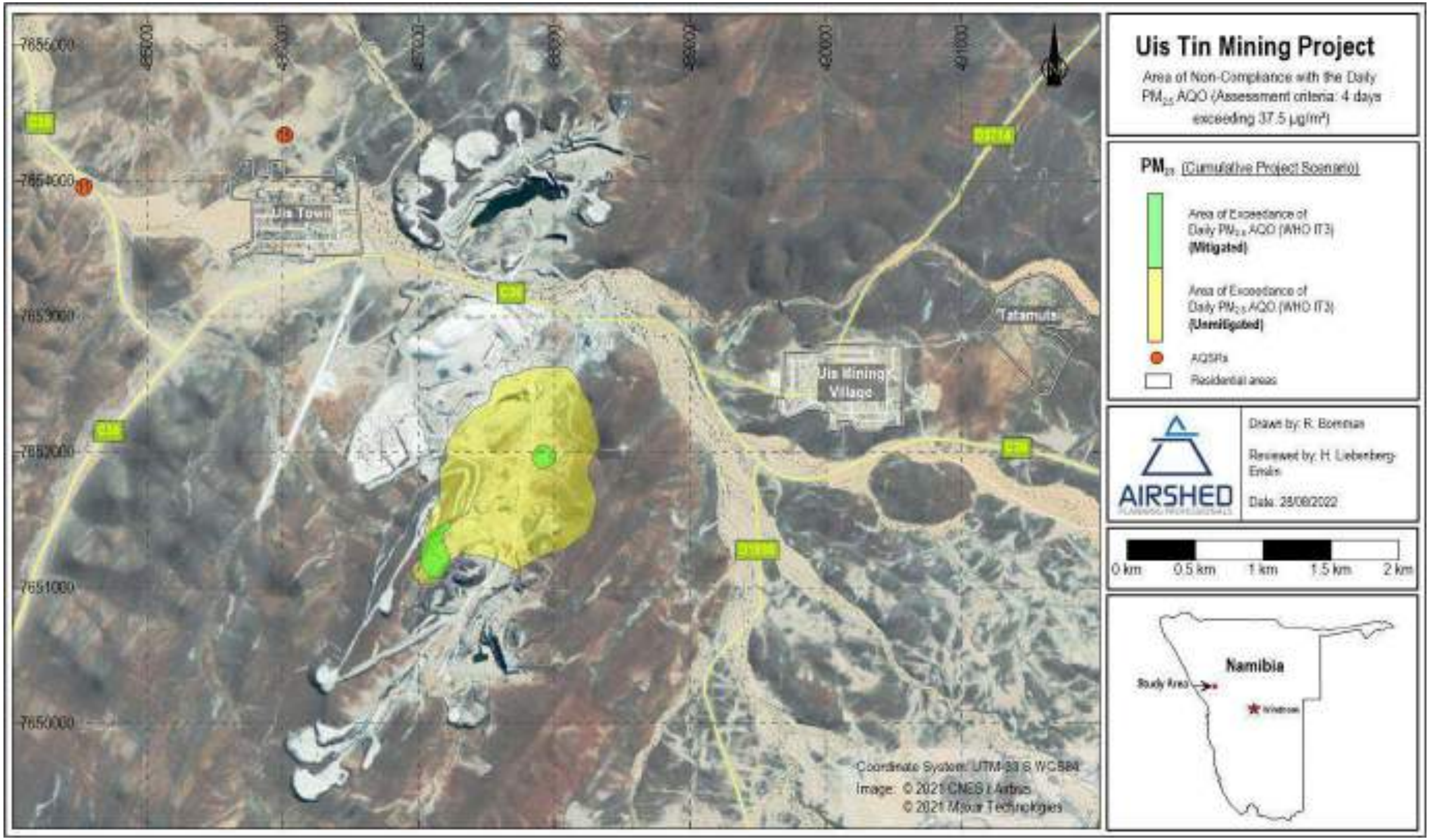

Figure 38: Area of non-compliance of annual $PM_{2.5}$ AQO for unmitigated and mitigated cumulative Project operations

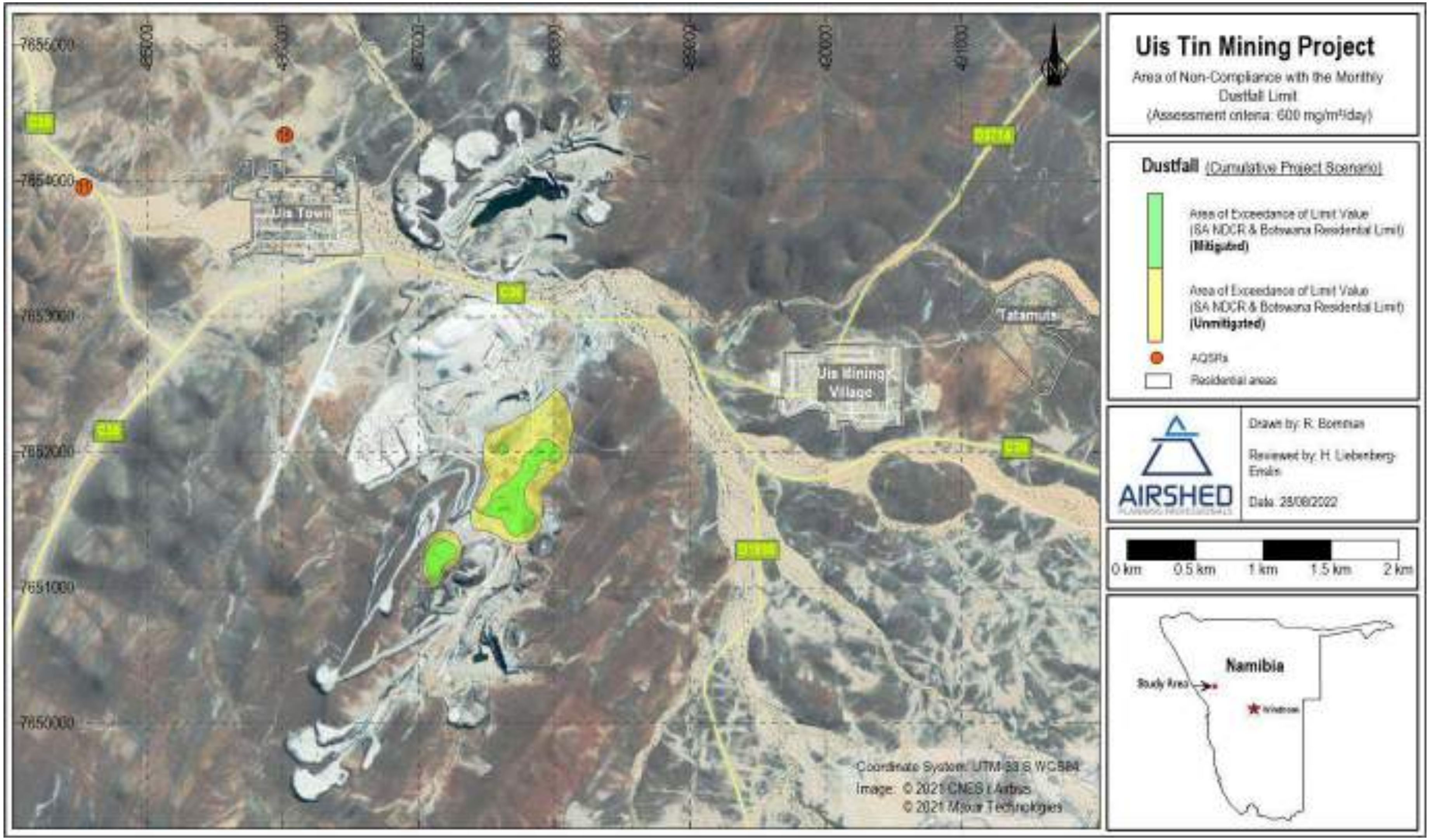

Figure 39: Area of non-compliance with the monthly dustfall AQO for unmitigated and mitigated cumulative Project operations

Table 21: Simulated PM_{10} and $PM_{2.5}$ ground level concentrations (in µg/m³) and maximum daily dustfall rates (in mg/m²/day) at selected AQSRs for cumulative Petalite Beneficiation Plant and Project operations

AQSR	PROJECT (CUMULATIVE)					
	Unmitigated			Mitigated		
	PM2.5 Highest Day	**PM10 Highest Day**	**Dust Fallout Highest Monthly**	**PM2.5 Highest Day**	**PM10 Highest Day**	**Dust Fallout Highest Monthly**
AQO	37.5 µg/m³	75 µg/m³	600 mg/m2/day	37.5 µg/m³	75 µg/m³	600 mg/m2/day
0	2.93	14.73	0.65	1.00	2.78	0.28
1	2.67	12.28	0.56	0.99	2.73	0.26
2	2.75	13.17	0.62	1.05	2.92	0.28
3	2.86	14.32	0.64	0.95	2.77	0.27
4	2.84	13.76	0.66	1.08	3.03	0.30
5	2.81	13.18	0.64	1.12	2.76	0.29
6	2.65	12.61	0.60	1.08	2.64	0.27
7	2.87	14.45	0.65	0.97	2.96	0.27
8	2.16	11.01	0.84	0.69	1.99	0.20
9	2.08	10.60	0.85	0.66	2.09	0.20
10	2.04	10.39	0.8	0.66	1.99	0.19
11	3.22	15.91	1.48	0.88	2.58	0.36
12	3.34	16.76	1.06	0.97	3.15	0.72
13	3.28	16.13	0.99	0.94	3.03	0.67
14	3.34	16.55	1.27	1.02	3.13	0.89
15	4.32	21.04	1.56	1.16	4.01	0.99
16	2.64	13.87	0.54	0.80	2.87	0.13
17	1.54	7.48	0.34	0.40	1.35	0.10
18	4.26	21.06	2.53	1.31	4.11	0.69
19	2.77	13.50	1.02	0.89	2.40	0.25
Uis Town	5.91	29.05	4.72	1.66	4.93	1.26
Uis Village	5.34	26.07	1.84	1.09	3.46	0.84
Tatamutsi	2.13	10.65	0.53	0.56	1.59	0.19

Notes:

CUMULATIVE: Mining: Mitigation includes 75% control efficiency (CE) on unpaved surface roads and 50% CE on unpaved in-pit roads (using water sprays), 50% CE on primary and secondary crushing and materials handling operations (using water sprays), >75% CE for tertiary and fines crushing and screening (wet process); Beneficiation plant: 50% CE on primary and secondary crushing and materials handling operations (using water sprays), 75% CE on unpaved surface roads, >90% CE on drying, classifying and product storage through fabric filter control.

6 RECOMMENDED AIR QUALITY MANAGEMENT MEASURES

In the light of the Project being so close to Uis Town and the Uis Mining Village it is recommended that Uis Tin Mine commit itself to adequate air quality management planning throughout the life of the Project.

The air quality management plan in this section provides options on the control of particulate matter at the main sources, while the monitoring network is designed to track the effectiveness of the mitigation measures.

Based on the findings of the impact assessment, site-specific management objectives are developed in Section 6.3 based on the ranking of emissions sources.

6.1 Air Quality Management Objectives

The main objective of the proposed air quality management measures for the Project is to ensure that operations result in ambient air concentrations (specifically $PM_{2.5}$ and PM_{10}) and dustfall rates that are within the relevant ambient air quality standards and regulations outside the mining area and at the relevant AQSRs. In order to define site specific management objectives, the main sources of pollution need to be identified. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

6.1.1 Ranking of Sources

The ranking of sources serves to confirm the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources ranking can be established on:

- Emissions ranking; based on the comprehensive emissions inventory established for the operations (Section 4.1); and
- Impacts ranking; based on the simulated pollutant GLCs.

Sources were ranked based on PM_{10} emissions and PM_{10} GLCs simulated at the 5 nearest AQSRs, since PM_{10} impacts were considered most significant among the three pollutants assessed.

Ranking of source- based quantified emissions and impacts for the operational phase are as follows:

- **Project operation**: For the operational phase, PM_{10} emissions due to *unmitigated* Baseline and Project activities are dominated by unpaved roads and crushing, followed by in-pit operations (Figure 15(a) and (c)), whereas for *mitigated* activities, in-pit sources and unpaved roads are the main contributors to total PM_{10} emissions (Figure 15(b) and (d)). PM_{10} impacts at the 5 nearest AQSRs, viz. SR11, SR18, Uis Town, Uis Mining Village and Tatamutsi, due to *unmitigated* Baseline and Project activities are mainly due to crushing (Figure 40(a) and (c)). For *mitigated* Baseline activities (Figure 40(b)), crushing, in-pits and roads contribute equally to PM_{10} impacts at receptors to the northwest of the Project (i.e. SR11, SR18 and Uis Town), whereas crushing is the dominant source of impacts at receptors to the northeast of the project (i.e. Uis Mining Village and Tatamutsi). For *mitigated* Project activities (Figure 40(d)), in-pit sources and unpaved roads contribute equally to PM_{10} impacts at SR11, SR18 and Uis Town, whereas unpaved roads is the dominant source of impacts at Uis Mining Village and Tatamutsi.

- **Petalite Beneficiation Plant**: Drying and Classifying is the main source of PM_{10} and $PM_{2.5}$ emissions from this process, followed by unpaved roads for PM_{10} and crushing and screening for $PM_{2.5}$. The main source of TSP emissions is crushing and screening, followed by unpaved roads.

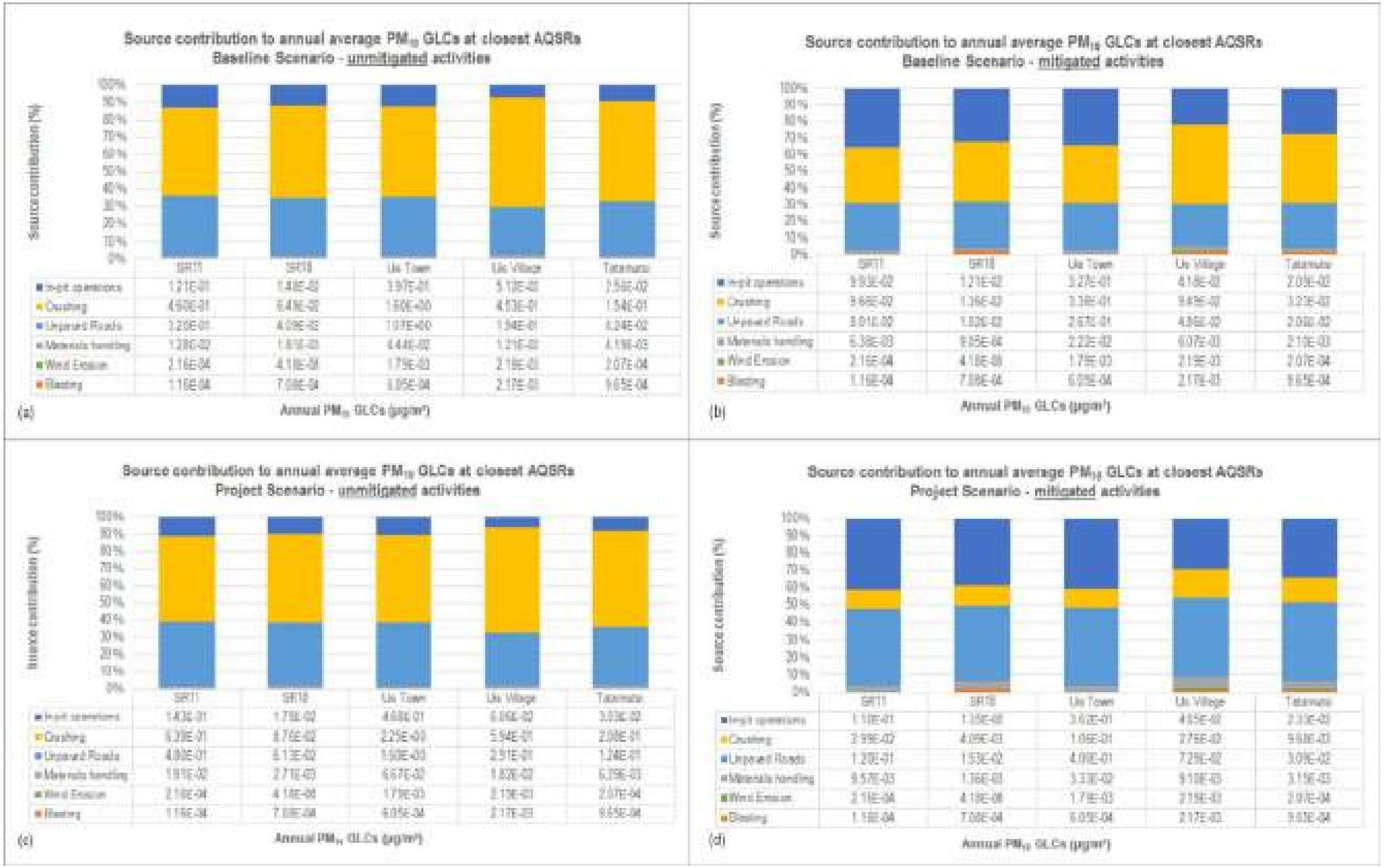

Figure 40: Source contribution to simulated annual average PM10 GLCs at the closest AQSRs

6.2 Proposed Mitigation Measures and Target Control Efficiencies

From the above discussion, it is recommended that the Project include the following mitigation measures:

- In controlling vehicle entrained PM, it is recommended that water be applied on in-pit haul roads to ensure a CE of at least 50% and that water in excess of 2 litres/m²/hr be applied on surface haul roads to ensure a CE of at least 75%.
- In controlling dust from crushing and screening operations, it is understood that the primary and secondary crushers will achieve 99% CE by using a dual scrubber, whereas plants that use wet suppression systems and use spray nozzles can effectively control PM emissions due to tertiary/fines crushing and screening (achieving upwards of 75% CE).
- Mitigation of materials transfer points should be done using water sprays at all tip points. This should result in a 50% control efficiency. Regular clean-up at loading points is recommended to avoid re-entrainment.
- Minimising windblown dust from the CPF and WRDs can be controlled through vegetation on the CPF side walls and keeping the dried-out areas at the CPF wet, and vegetation cover on the side walls of the WRDs.
- Controlling dust from Drying and Classification can be done using fabric filters. This should result in 90% CE.

Further literature on source specific mitigation measures is provided in Section 9.2.

6.3 Performance Indicators

Key performance indicators against which progress of implemented mitigation and management measures may be assessed form the basis for all effective environmental management practices. In the definition of key performance indicators, careful attention is usually paid to ensure that progress towards their achievement is measurable, and that the targets set are achievable given available technology and experience.

Performance indicators are usually selected to reflect both the direct source of the emission (source monitoring) and the impact on the receiving environment (ambient air quality monitoring). For instance, ensuring that no visible evidence of windblown dust exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels to below 600 mg/m²/day represents an impact- or receptor-based performance indicator.

6.3.1 Ambient Air Quality Monitoring

Ambient air quality monitoring can serve to meet various objectives, such as:

- Compliance monitoring;
- Validate dispersion model results;
- Use as input for health risk assessment;
- Assist in source apportionment and source quantification;
- Temporal and spatial trend analysis; and
- Tracking progress made by control measures.

It is recommended that the current dustfall monitoring network, comprising of fourteen (14) single dustfall units, should be maintained and the monthly dustfall results used as indicators to track the effectiveness of the applied mitigation measures. Dustfall collection should follow the American Society for Testing and Materials (ASTM) method.

6.4 Periodic Inspections, Audits and Community Liaison

6.4.1 Periodic Inspections and Audits

Periodic inspections and external audits are essential for progress measurement, evaluation and reporting purposes. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly), with annual environmental audits being conducted. Annual environmental audits should be continued at least until closure. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the management plan. Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event of unsatisfactory progress towards targets as indicated by the quarterly/annual reviews.

6.4.2 Liaison Strategy for Communication with Interested and Affected Parties (I&APs)

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. Management plans should stipulate specific intervals at which forums will be held and provide information on how people will be notified of such meetings. Since the operations are located in close proximity (within 2 km) from community areas, it is recommended that such meetings be scheduled and held on a regular basis.

6.5 Impact Significance Rating

The significance of environmental air quality impacts was assessed according to the methodology adopted by ECC. The definitions of the significance ratings and EIA ratings matrix are provided in Appendix C.

Even though the project activities are in close proximity of potential AQSRs, the significance of construction and operation phase air quality impacts (including the ESIA Amendment) is ***minor.*** The impact assessment has been provided in a separate impact assessment spreadsheet to ECC.

7 Conclusions And Recommendations

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Compliance Consultancy (ECC) to undertake a specialist air quality impact study for the proposed Phase 1 Fast-Tracked Stage II expansion of the Uis Tin Mine.

The main objective of the air quality specialist study was to determine the potential for dust on the surrounding people and environment, and to provide practical mitigation measures on how to reduce the potential impacts. The investigation followed the methodology required for a specialist report, comprising the baseline characterisation and the impact assessment study.

7.1 Baseline characterisation

The Uis Project is located near the town of Uis, approximately 164 km north of Swakopmund and 30 km northwest of the Brandberg mountain, Namibia's highest mountain (2 559 m above sea level). The closest residential developments to the Project consist of Uis (~1.9 km to the northwest), Uis Mining Village (~1.7 km to the east) and Tatamutsi (~3.4 km to the east). Individual farmsteads also surround the Project area.

On-site meteorological data was not available. Use was made of Weather Research and Forecasting Model (WRF) simulated meteorological data for the period 2018 – 2020 for a location at the mine.

The baseline characterisation can be summarised as follows:

- The wind field in the area is dominated by winds from the southwest during the day and night, with an increase in winds from the south-southwest and south during the night. Day- and night-time average wind speeds are 4.6 m/s and 5.0 m/s respectively. Calm conditions occur 3.0% of time during the day and 2.5% during the night. On average, air quality impacts are expected to be slightly more notable to the north and north-east of the Project.
- The predominant south-south-westerly, southerly and north-north-easterly winds in the study region may be explained by the topography of the study area. Uis is ~800 m above sea level with the highest point at 900 m above sea level. The terrain is fairly flat in the immediate vicinity of the plant site, with steeper and higher relief areas confined to the northeast and south. The highest wind speeds (more than 6 m/s) were recorded during summer and springtime and are mostly from the south-southwest and southwest.
- Maximum, minimum, and mean temperatures were given as 39.9°C, 1.2°C and 22.5°C respectively from the WRF data for the period Jan 2018 to Dec 2020.
- Average annual rainfall at Uis town for the period 2009 to 2021 was given as 656 mm, with most rain recorded during the summer (December to March) and least during the winter months from May to September.
- The main pollutant of concern in the region is particulate matter (TSP; PM_{10} and $PM_{2.5}$) resulting from vehicle entrainment on the roads, windblown dust, mining and exploration activities.
- Sources of atmospheric emissions in the vicinity of the Project include small-stock farming, small-scale mining, activities of the Namclay Brick and Pavers factory, dust generated from historically mined areas and, to a lesser extent, emissions from vehicle tailpipes along the C36 and D1930 public roads. Other regional sources that may have an influence on the ambient air quality around the Project are biomass burning (natural bush fires or those employed for agricultural purposes) and de-bushing to increase the grazing capacity of farmland. Given these activities, it is expected that fugitive dust may be present during dry, windy conditions. However, the contribution of all these sources to existing ambient air quality is considered very low, especially in a low-density population area such as the one where the Uis mine is located.

- Regional scale transport of mineral dust and ozone (due to vegetation burning) from the north of Namibia is a potential contributing source to background PM concentrations.
- There is no ambient air quality data available for the study site. PM concentrations measured as part of the SEMP AQMP monitoring network were limited to the coastal towns of Swakopmund, Walvis Bay and Henties Bay with a station in the central western part of the region on the farm Jakalswater. None of these locations are representative of the air quality in the Uis area.
- Dustfall monitoring data was provided for the period March 2019 to August 2021. The monitoring network comprised of eight (8) single dustfall units between March 2019 and November 2020 but has been expanded to fourteen (14) single dustfall units from December 2020 forward. Dustfall rates were generally low for the sampling period and well within the dustfall limit of 600 mg/m²/day (adopted limit for residential areas) and 1 200 mg/m²/day (adopted limit for non-residential areas), with the exception of AQ 01 (5 exceedances in 2020 and 4 exceedances in 2021), AQ 05 (2 exceedances in 2019, 5 exceedances in 2020 and 1 exceedance in 2021), AQ 08 (1 exceedance in 2019) and AQ 14 (1 exceedance in 2020).

7.2 Impact Assessment

Emissions due to the construction of the secondary crushing and screening plant as well as the DMS feed stockpile were quantified using area-wide emission factors for general construction activities. A quantitative air quality impact assessment was conducted for the operational phase activities of the Uis project. The assessment included an estimation of atmospheric emissions, the simulation of pollutant concentrations and determination of the significance of impacts.

The impact assessment was limited to airborne particulate (including TSP, PM_{10} and $PM_{2.5}$). Gaseous emissions (i.e. SO_2, NOx, CO and VOCs) were not included and will primarily result from diesel combustion and from mobile and stationary sources.

7.2.1 Construction Phase

- The construction phase during Stage II was designed to allow pre-assembly while the plant is in operation. Construction work include civil works, in-plant erection, piping, erection of conveyors and gantries, conveyor mechanical installation, and electrical, control and instrumentation work. The largest construction works (in terms of land area) are the construction of a new secondary crushing and screening plant and a DMS feed stockpile. The total land area was determined from georeferenced site plans as approximately 1 320 m^2.
- Using US-EPA emissions factors for general construction activities, and assuming that the quantity of dust emissions is proportional to the area of land being worked and the level of construction activity, construction emissions were estimated at 355 kg for TSP, 138 kg for PM_{10} and 69 kg for $PM_{2.5.}$
- Due to the intermittent nature of construction operations, construction impacts are expected to have a small but potentially harmful impact at the nearest AQSRs depending on the level of activity. With mitigation measures in place these impacts are expected to have **minor** significance.

7.2.2 Operational Phase

- Two mining scenarios were assessed to determine the increase in impacts due to the Project, namely a Baseline scenario and Project Scenario. It was assumed that Stage I throughputs as provided in the Definitive Feasibility Study (DFS) summary represent the Baseline scenario (current mining rates) and that Stage II throughputs represent the Project scenario (future mining rates required to support the expanded MHCP). V1 and V2 opencast areas were assumed to be mined concurrently in a 57:43 tonnage split.

- Emissions quantified for the Uis Project were restricted to fugitive releases (non-point releases) with particulates the main pollutant of concern. Emissions were quantified based on provided information on mining rates and mine layout plan.
  - Quantified PM_{10} and $PM_{2.5}$ emissions were similar for unmitigated Baseline and Project operations. TSP emissions were higher for the unmitigated Project Scenario. Quantified PM_{10}, $PM_{2.5}$ and TSP emissions were higher for design mitigated Project operations than its counterpart Baseline operations, apart from crushing activities (due to the high control efficiency of the dual scrubber on the primary and secondary crushers for the Project Scenario).
  - The main sources of controlled $PM_{2.5}$, PM_{10} and TSP emissions due to the Project scenario are, in order of importance: i) in-pit operations (including in-pit haul roads, materials handling and drilling), ii) vehicle entrainment from unpaved surface roads, iii) wind erosion from the WRD, CPF and ROM stockpiles, iv) crushing and screening (primary; secondary, tertiary and fines) operations, v) materials handling and vi) blasting, with blasting a lesser source due to its intermittent nature and variable duration.
- For each of the two scenarios, unmitigated and mitigated options were modelled. Mitigation was applied based on design mitigation measures provided, which included the following:
  - in-pit haul roads: water sprays assuming 50% control efficiency (CE);
  - surface haul roads: water sprays assuming 75% CE;
  - crushing and screening of ROM (primary and secondary): assuming 99% CE for dual scrubber;
  - crushing and screening of ROM (tertiary and fines): >75% CE for wet processes; and
  - materials handling, including conveyor transfer: assuming 50% CE for water sprays.
- Dispersion modelling results for the Baseline Scenario:
  - PM_{10} daily GLCs, for unmitigated activities, result in exceedances of the 24-hour air quality objective (AQO) over a maximum distance of ~700 m from Uis mining activities, but with no exceedances at any of the AQSRs. For mitigated activities, impacts are limited to the Uis mining and processing plant areas with no exceedances at any of the AQSRs. PM_{10} annual GLCs, for both unmitigated and mitigated activities, are within the AQO at the AQSRs.
  - $PM_{2.5}$ daily GLCs, for unmitigated activities, do not exceed the AQO (WHO IT-3) at any of the AQSRs but the footprint of exceedance extends ~300 m off-site. For mitigated activities, there are no exceedances at any of the AQSRs and impacts are limited to on-site areas. There are no exceedances of the annual $PM_{2.5}$ AQO, without and with mitigation in place.
  - Maximum daily dustfall rates, for both unmitigated and mitigated activities, do not exceed the AQO (SA NDCR residential limit of 600 mg/m²/day) at any of the AQSRs.
- Dispersion modelling results for the Project Scenario:
  - The daily PM_{10} AQO (WHO IT-3 and SA NAAQS) is exceeded over a maximum distance of 950 m from the Uis mining area (with no mitigation in place) but reduce to smaller areas of exceedance on-site when mitigation is applied. PM_{10} daily GLCs, for unmitigated and mitigated activities, do not result in any exceedances of the 24-hour AQO at the AQSRs. Over an annual average there are no exceedances at any of the AQSRs, without and with mitigation.
  - For daily $PM_{2.5}$ the area of maximum unmitigated GLCs exceedance extends northwest from the Uis mining operations over a maximum distance of ~750 m, with no exceedances at any of the AQSRs. With mitigation in place there are no exceedances at any of the AQSRs and the impact is reduced to much smaller areas of exceedance. Annual average $PM_{2.5}$ GLCs are low at all AQSRs.

    - Maximum daily dustfall rates, for both unmitigated and mitigated activities, are within the AQO (SA NDCR residential limit of 600 mg/m²/day) at all of the AQSRs.
- For both the Uis Baseline and Project Scenarios, the significance is expected to be **minor** with and without mitigation in place.
- Cumulative air quality impacts could not be assessed since no background PM_{10} and $PM_{2.5}$ data are available. The localised PM_{10} and $PM_{2.5}$ impacts from the Uis modelling results indicate the potential for low regional cumulative impacts, resulting in **minor** significance.

7.3 Impact Assessment Amendment

Subsequent to the initial impact assessment (referred to as the Project), additional changes will be made to the processing operations including a bulk sampling and ore sorting and testing facility (referred to as the Petalite Beneficiation Plant) to extract the lithium-bearing ore.

- Two operational scenarios were assessed, namely the incremental and cumulative Petalite Beneficiation Plant scenarios, each with an unmitigated and mitigated sub-scenario.
- Emissions for the Petalite Beneficiation Plant were quantified based on provided information on processing rates and plant layout.
    - Drying and Classifying is the main source of PM_{10} and $PM_{2.5}$ emissions from this process, followed by unpaved roads for PM_{10} and crushing and screening for $PM_{2.5}$. The main source of TSP emissions is crushing and screening, followed by unpaved roads.
- Dispersion modelling results for the incremental Petalite Beneficiation Plant
    - Simulated values for PM_{10}, $PM_{2.5}$ and maximum daily dustfall rates at AQSRs are negligibly small.
    - PM_{10} and $PM_{2.5}$ daily GLCs, for unmitigated activities, result in exceedances of the 24-hour air quality objective (AQO) over a maximum distance of ~90 m from on-site activities.
    - The footprint of exceedance of maximum daily dustfall rates exceed the AQO within 125 m from the facility's activities.
- Cumulative air quality impacts (the Project and the Petalite Beneficiation Plant)
    - The cumulative plots including the Petalite Beneficiation Plant are not significantly different from those for the Project Scenario described in Section 7.2.2. The numerical results simulated at the AQSRs are also not significantly different from those simulated for the Project only. It may therefore be concluded that the conclusions from this report would not change as a result of the Petalite Beneficiation Plant.

7.4 Conclusion

The proposed Uis Project (including the Petalite Beneficiation Plant) is not likely to result in $PM_{2.5}$ and PM_{10} ground level concentrations in exceedance of the selected AQOs at any of the AQSRs, for both unmitigated and mitigated activities. Impacts due to unmitigated activities are likely to extend over a localised area around mining activities, and around the Petalite Beneficiation Plant. With mitigation in place, the resulting impacts can be limited to on-site areas. Dustfall rates are likely to be low throughout the life of mine.

It is the specialist's opinion that the proposed project could be authorised provided strict enforcement of mitigation measures and the tracking of the effectiveness of these measures to ensure the lowest possible off-site impacts.

7.5 Recommendations

The most practical approach in controlling PM emissions would be the application of water sprays where and as often as possible. Other measures are also proposed. These include:

- Construction phase:
    - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks; limiting unnecessary travelling of vehicles on untreated roads; and applying water suppression to achieve a control efficiency (CE) of 75%.
    - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
- Operational phase:
    - Control of vehicle entrained dust with a CE of 75% on unpaved surface roads through water suppression, and water sprays on the in-pit haul roads, to ensure a 50% CE.
    - In controlling dust from crushing and screening operations, it is understood that the primary and secondary crushers will achieve 99% CE by using a dual scrubber, whereas plants that use wet suppression systems and use spray nozzles can effectively control PM emissions due to tertiary/fines crushing and screening (achieving upwards of 75% CE).
    - Mitigation of materials transfer points should be done using water sprays at all tip points. This should result in a 50% control efficiency. Regular clean-up at loading points is recommended to avoid re-entrainment.
    - Minimising windblown dust from the CPF and WRDs can be done through vegetation on the CPF side walls and keeping the dried-out areas at the CPF wet, and vegetation cover on the side walls of the WRDs.
    - Controlling dust from Drying and Classifying can be done using fabric filters. This should result in 90% CE.
- Air Quality Monitoring:
    - The current dustfall monitoring network, comprising of fourteen (14) single dustfall units, should be maintained and the monthly dustfall results used as indicators to track the effectiveness of the applied mitigation measures. Dustfall collection should follow the American Society for Testing and Materials (ASTM) method.

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9 Appendix

9.1 Appendix A – Monitoring Methodology

9.1.1 Dustfall Sampling

It is recommended that the dustfall network comprise of single dustfall buckets following the American Society for Testing and Materials (ASTM) standard method for collection and analysis of dustfall (ASTM D1739-98). This method employs a simple device consisting of a cylindrical container (not less than 150 mm in diameter) exposed for one calendar month (30 ± 2 days). Even though the method provides for a dry bucket, de-ionised water can be added to ensure the dust remains trapped in the bucket.

The bucket stand comprises a wind shield at the level of the rim of the bucket to provide an aerodynamic shield. The bucket holder is connected to a 2m galvanized steel pole, which is attached to a galvanized steel base plate. This allows for a variety of placement options for the fallout samplers (Figure 41). Exposed buckets, when returned to the laboratories, are rinsed with deionised water to remove residue from the sides of the bucket, and the bucket contents filtered through a coarse (>1 mm) filter to remove insects and other course organic detritus. The sample is then filtered through a pre-weighed paper filter to remove the insoluble fraction, or dustfall. This residue and filter are dried, and gravimetrically analysed to determine the insoluble fraction (dustfall).

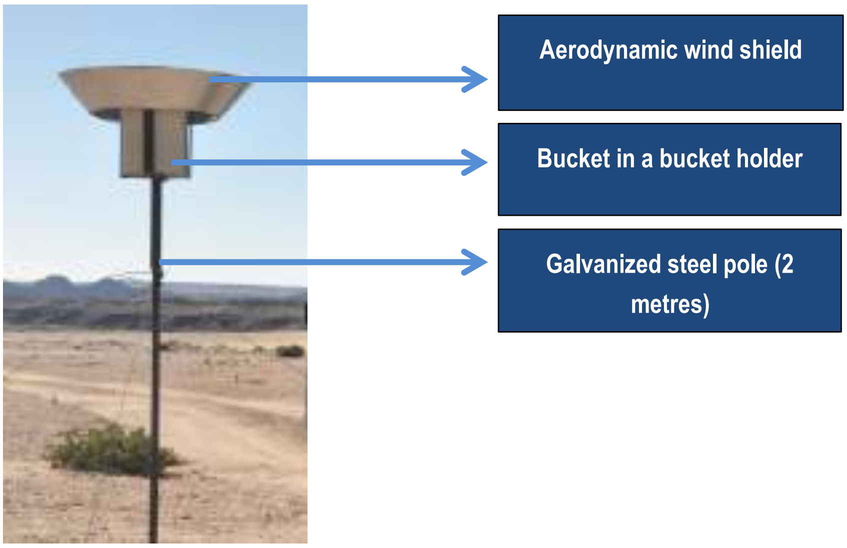

Figure 41: Example of a dustfall bucket

9.2 Appendix B – Source Specific Management and Mitigation Measures

9.2.1 Dust Control Options for Unpaved Roads

Three types of measures may be taken to reduce emissions from unpaved roads:

- Measures aimed at reducing the extent of unpaved roads, e.g. paving;
- Traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds; and
- Measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (Cowherd, et al., 1988).

The main dust generating factors on unpaved road surfaces include:

- Vehicle speeds;
- Number of wheels per vehicle;
- Traffic volumes;
- Particle size distribution of the aggregate;
- Compaction of the surface material;
- Surface moisture; and
- Climate

According to research conducted by the Desert Research Institute at the University of Nevada, an increase in vehicle speed of 16 km per hour resulted in an increase in PM_{10} emissions of between 1.5 and 3 times. A similar study conducted by Flocchini (Flocchini, et al., 1994) found a decrease in PM_{10} emissions of 42±35% with a speed reduction from 40 km/hr to 24 km/hr (Stevenson, 2004). An evaluation of control efficiencies resulting from reductions in traffic volumes can be calculated due to the linear relationship between traffic volume, given in terms of vehicle kilometres travelled, and fugitive dust emitted. Similar affects will be achieved by reducing the truck volumes on the roads.

Water sprays on unpaved roads is the most common means of suppressing fugitive dust due to vehicle entrainment, but it is not necessarily the most efficient means (Thompson & Visser, 2000). Thompson and Visser (2000) developed a model to determine the cost and management implications of dust suppression on haul roads using water or other chemical palliatives. The study was undertaken at 10 mine sites in Southern Africa. The model was first developed looking at the re-application frequency of water required for maintaining a specific degree of dust palliation. From this the cost effectiveness of water spray suppression could be determined and compared to other strategies. Factors accounted for in the model included climate, traffic, vehicle speed and the road aggregate material. A number of chemical palliative products, including hygroscopic salts, lignosulponates, petroleum resins, polymer emulsions and tar and bitumen products were assessed to benchmark their performance and identify appropriate management strategies. Cost elements taken into consideration included amongst others capital equipment, operation and maintenance costs, material costs and activity related costs.

The main findings were that water-based spraying is the cheapest dust suppression option over the short term. Over the longer term however, the polymer-emulsion option is marginally cheaper with added benefits such as improved road surfaces during wet weather, reduced erosion and dry skid resistance (Thompson & Visser, 2000). The empirical model, developed by the US EPA (US EPA, 1996), can also be used to estimate the average control efficiency of certain quantifies of water applied to a road. The model takes into account rainfall, evaporation rates and traffic.

Chemical suppressant has been proven to be effective due to the binding of fine particulates in the road surface, hence increasing the density of the surface material. In addition, dust control additives are beneficial in the fact that it also improves the compaction and stability of the road. The effectiveness of a dust palliative includes numerous factors such as the application rate, method of application, moisture content of the surface material during application, palliative concentrations, mineralogy of aggregate and environmental conditions. Thus, for different climates and conditions you need different chemicals, one chemical might not be as effective as another under the same conditions and each product comes with various advantages and limitations of its own. In general, chemical suppressants are given to achieve a PM_{10} control efficiency of 80% when applied regularly on the road surfaces (Stevenson, 2004).

Spillage and track-on from the surrounding unpaved areas may result in the deposition of materials onto the chemically treated or watered road resulting in the need for periodic "housekeeping" activities (Cowherd, et al., 1988). In addition, the gradual abrasion of the chemically treated surface by traffic will result in loose material on the surface which would have to be controlled. The minimum frequency for the reapplication of watering or chemical stabilizers thus depends not only on the control efficiency of the suppressant but also on the degree of spillage and track-on from adjacent areas, and the rate at which the treated surface is abraded.

The best way to avoid dust generating problems from unpaved roads is to properly maintain the surface by grading and shaping to prevent dust generation caused by excessive road surface wear (Stevenson, 2004).

Table 22: Unpaved haul roads: Dust suppression improvement plan

Criteria	Description
Unpaved haul roads	• In-pit haul roads. • Haul roads between pits and processing plant • Haul roads to CPF and WRD
Operational hours	24 Hours per day, 7 days per week
Accountable person(s)	Environmental Officer; Mine Production Engineer Dust Suppression Contractor
Target control	At least 75%
Performance indicators	• Monthly physical inspection of road surface, daily visual observation of entrained dust emissions from unpaved road surfaces. • Dustfall rates less than 600 $mg.m^{-2}.day^{-1}$ at sensitive receptor locations. • Dustfall rates less than 1200 $mg.m^{-2}.day^{-1}$ at on-site locations.
Operating procedures	• Water suppression on all haul roads i.e. between the various pits and plants to ensure >75% control efficiency. • Truck speeds are one of the main parameters affecting entrainment emissions from unpaved roads, truck speeds should be kept as low as possible to minimise fugitive dust emissions. 20km/h is recommended.
Inspections	• Monthly inspections to ensure effectiveness of chemical stabilisation. • This can include daily visual inspections of the site coupled with the dustfall and ambient monitoring data

9.2.2 Crushing and Screening Operations

Enclosure of crushing operations is very effective in reducing dust. The Australian NPI (NPI, 2011) indicates that a telescopic chute with water sprays would ensure 75% control efficiency and enclosure of storage piles where tipping occurs would reduce the emissions by 99%. In addition, chemical suppressants or water sprays on the primary crusher and dry dust extraction units with wet scrubbers on the secondary crushers and screens will assist in the reduction of the cumulative dust impacts. According to the Australian NPI, water sprays can have up to 50% control efficiency and hoods with scrubbers up to 75%. If in addition, the scrubbers and screens were to be enclosed; up to 100% control efficiency can be achieved. Hooding with fabric filters can result in control efficiencies of 83%. It is important that the control equipment be maintained and inspected on a regular basis to ensure that the expected control efficiencies are met (NPI, 2011).

The moisture content of the material processed can have a substantial effect on emissions. This effect is evident throughout the processing operations. Surface wetness causes fine particles to agglomerate on or to adhere to the faces of larger stones, with a resulting dust suppression effect. However, as new fine particles are created by crushing and attrition and as the moisture content is reduced by evaporation, this suppressive effect diminishes and may disappear. Plants that use wet suppression systems (spray nozzles) to maintain relatively high material moisture contents can effectively control PM emissions throughout the process (US-EPA AP42, Chapter 11 Section 19.2.2).

Uncontrolled crushing and screening operations were shown to be a considerable source of dust emissions. Regular maintenance of mitigation measures is critical to meeting the minimum target for dust control. Other actions include regular inspection and clean-up of the crusher area, as well as reducing the loose material on the surface of the crusher area which will reduce the risk of re-entrainment by vehicles moving in the area. Wetting of the loose dust in between clean-up will also reduce potential emissions.

Table 23: Crushing: Dust suppression improvement plan

Criteria	Description
Crushing and Screening Operations	• Processing Plant
Operational hours	24 hours per day, 7 days per week
Accountable person(s)	Environmental Officer; Operator at crusher
Target control	At least 99% (via dual scrubber) at primary and secondary crushers Control efficiencies of >75% at tertiary and fines crushers by maintaining high material moisture content using spray nozzles
Performance indicators	• Regular maintenance of control equipment. • No loose dust around crushing facility • Dustfall rates less than 600 mg.m^{-2}.day^{-1} at sensitive receptor locations. • Dustfall rates less than 1200 mg.m^{-2}.day^{-1} at on-site locations.
Operating procedures	• Spillage clean up, at least once a week • Water spraying road surface in loading area.

9.2.3 Options for Reducing Windblown Dust Emissions

The main techniques adopted to reduce windblown dust potential include source extent reduction, source improvement and surface treatment methods:

- Source extent reduction:
  - Disturbed area reduction.
  - Disturbance frequency reduction.
  - Dust spillage prevention and/or removal.

- Source Improvement:
    - Disturbed area wind exposure reduction, e.g. wind fences and enclosure of source areas.
- Surface Treatment:
    - Wet suppression
    - Chemical stabilisation
    - Covering of surface with less erodible aggregate material
    - Vegetation of open areas

The suitability of the dust control techniques indicated will depend on the specific source to be addressed, and will vary between dust spillage, material storage and open areas. The NPI (2011) recommends the following methods for reducing windblown dust:

- Primary rehabilitation - 30%
- Vegetation established but not demonstrated to be self-sustaining. Weed control and grazing control - 40%
- Secondary rehabilitation - 60%
- Re-vegetation - 90%
- Fully rehabilitated (release) vegetation - 100%

Table 24: Wind erosion sources: Dust suppression improvement plan

Criteria	Description	Comments
Wind Blown Dust		• ROM storage pile • Waste rock dump • Co-placement facility
Operational hours	During periods with high wind speeds	
Accountable person(s)	Environmental Officer Mining Engineer	
Target control	At least 50%	
Performance indicators	• Dustfall rates less than 600 $mg.m^{-2}.day^{-1}$ at sensitive receptor locations. • Dustfall rates less than 1200 $mg.m^{-2}.day^{-1}$ at on-site locations. • No dust should be visible from the WRD, CPF or ROM stockpiles during episodes of strong winds.	
Operating procedures	• Water sprays at ROM stockpiles and product stockpiles can achieve 50% control efficiency. Increase in moisture content provides higher threshold friction velocity and ensures that particulates are not as easily entrained due to high surface winds. • Reshape all disturbed areas to their natural contours. • Cover disturbed areas with previously collected topsoil and replant native species. • Rock cladding with larger pieces of waste rock is recommended to reduce wind erosion emissions from the overburden storage piles • Backfilling or revegetation of overburden stockpiles is recommended.	

9.3 Appendix C – Impact Significance Rating Methodology

The significance of air quality related impacts was assessed using the risk rating matrix provided by ECC (Table 26). Significance definitions are provided below (Table 25). The numbers corresponding to each significance category are calculated by multiplying the sensitivity of the receptor with the significance of the impact.

Table 25: Definitions of significance ratings

7 to 12	**Major**	An impact of major significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. A goal of the EIA process is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be major residual. Impacts are expected to be permanent and non-reversible on a national scale and/or have international significance or result in legislative non-compliance.
4 to 6	**Moderate**	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level as low as reasonably practicably. This does not necessarily mean that 'moderate' impacts have to be reduced to 'minor' impacts, but that moderate impacts are being managed effectively and efficiently. Impacts are long-term, but reversible and/or have regional significance.
3 to 4	**Minor**	An impact of minor significance is one where an effect will be experienced, but the impact magnitude is sufficiently small (with and without mitigation) and well within accepted standards, and/or the receptor is of low sensitivity/value. Impacts are considered to be short-term, reversible and/or localised in extent.
1 to 2	**Low**	An impact of low significance (or an insignificant impact) is where a resource or receptor (including people) will not be affected in any way by a particular activity, or the predicted effect is deemed to be 'negligible' or 'imperceptible' or is indistinguishable from natural background variations.

Table 26: EIA significance matrix

				Significance of Impact			
			Significance of Impact	Impacts are considered to be local factors that are unlikely to be critical to decision-making.	Impacts are considered to be important factors but are unlikely to be key decision-making factors. The impact will be experienced, but the impact magnitude is sufficiently small (with and without mitigation) and well within accepted standards, and/or the receptor is of low sensitivity/value. Impacts are considered to be short-term, reversible and/or localised in extent.	Impacts are considered within acceptable limits and standards. Impacts are long-term, but reversible and/or have regional significance. These are generally (but not exclusively) associated with sites and features of national importance and resources/features that are unique and which, if lost, cannot be replaced or relocated.	Impacts are considered to be key factors in the decision-making process that may have an impact of major significance, or large magnitude impacts occur to highly valued/sensitive resource/receptors. Impacts are expected to be permanent and non-reversible on a national scale and/or have international significance or result in legislative non-compliance.
	Biophysical	**Social**		**Low (1)**	**Minor (2)**	**Moderate (3)**	**Major (4)**
Sensitivity	A biophysical receptor that is protected under legislation or international conventions listed as rare threatened or endangered IUCN species. Highly valued/sensitive resource/receptors.	Those affected people/communities will not be able to adapt to changes or continue to maintain pre-impact livelihoods.	**High (3)**	**Minor (3)**	**Moderate (6)**	**Major (9)**	**Major (12)**
	Of value, importance or rarity on a regional scale, and with limited potential for substitution; and/or not protected or listed globally but may be a rare or threatened species in country; with little resilience to ecosystem changes, important to ecosystem functions, or one under threat or population decline.	Able to adapt with some difficulty and maintain preimpact status but only with a degree of support.	**Medium (2)**	**Low (2)**	**Minor (4)**	**Moderate (6)**	**Major (8)**
	Not protected or listed as common/abundant; or not critical to other ecosystems functions	Those affected are able to adapt with relative ease and maintain preimpact status. There is no perceptible change to people's livelihood.	**Low (1)**	**Low (1)**	**Low (2)**	**Minor (3)**	**Moderate (4)**

Environmental Noise Impact Assessment for the Uis Tin Mine, Phase 1 Fast-Tracked Stage II

Project done for **Environmental Compliance Consultancy**

Report compiled by:
Reneé von Gruenewaldt

Report No: 21ECC01N | **Date:** January 2022

Address: 480 Smuts Drive, Halfway Gardens | Postal**:** P O Box 5260, Halfway House, 1685
Tel: +27 (0)11 805 1940 | Fax**:** +27 (0)11 805 7010
www.airshed.co.za

Report Details

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Prepared by	Renee von Gruenewaldt, (Pr. Sci. Nat.), MSc (University of Pretoria)
Reviewed by	Nick Grobler, BEng (Chem) BEng (Hons) (Env) (University of Pretoria)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in air quality, environmental noise and climate change impacts assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
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Revision Record

Version	Date	Comments
Rev 0	January 2022	For client review

Glossary and Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
dB	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure.
dBA	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure that has been A-weighted to simulate human hearing.
DMS	Dense Medium Separation
ECC	Environmental Compliance Consultancy
EHS	Environmental, Health, and Safety (IFC)
Hz	Frequency in Hertz
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Standards Organisation
km	kilometre
kW	Power in kilowatt
L_{Aeq} (T)	The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
L_{A90}	The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels (L_{A90}) (in dBA)
L_{AFmax}	The A-weighted maximum sound pressure level recorded during the measurement period
L_{AFmin}	The A-weighted minimum sound pressure level recorded during the measurement period
L_P	Sound pressure level (in dB)
Ltd	Limited
L_W	Sound Power Level (in dB)
masl	Meters above sea level
MHCP	Materials Handling and Concentrating Plant
m^2	Area in square meters
mm	Millimetre
m/s	Speed in meters per second
Mtpa	Million tonnes per annum
NSR	Noise sensitive receptor
NACA	National Association for Clean Air
NEMA	National Environmental Management Act
NEMAQA	National Environmental Management Air Quality Act
p	Pressure in Pa
Pa	Pressure in Pascal
µPa	Pressure in micro-pascal
p_{ref}	Reference pressure, 20 µPa

Pty	Proprietary
SABS	South African Bureau of Standards
SACNASP	South African Council for Natural Scientific Professions
SANS	South African National Standards
SLM	Social and Labour Plan
SoW	Scope of Work
STRM	Shuttle Radar Topography Mission
USGS	United States Geological Survey
VGF	Vibrating Grizzly Feeder
WHO	World Health Organisation
WRF	The Weather Research and Forecasting (WRF) Model
°C	Degrees Celsius
%	Percentage

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Compliance Consultancy (ECC) to undertake a specialist environmental noise impact study for the proposed Phase 1 Fast-Tracked Stage II expansion of the Uis Tin Mine (hereafter referred to as the project).

The main objective of the noise specialist study was to determine the potential impact on the acoustic environment and noise sensitive receptors (NSRs) as a result of the proposed operations and to recommend suitable management and mitigation measures.

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps and field observations;
    b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data sources; and
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from surveys conducted for the site.
4. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Noise propagation simulations to determine environmental noise levels as a result of the project.
    c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist noise impact assessment report.

In the assessment of simulated noise levels, reference was made to the IFC noise level guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night). To assess annoyance at nearby places of residence, the increase in noise levels above the baseline at NSRs were calculated and compared to guidelines published in the SANS 10103.

The baseline acoustic environment was described in terms of the location of NSRs, the ability of the environment to attenuate noise over long distances, as well as existing background and baseline noise levels. The following was found:

- The closest residential developments to the proposed project consist of Uis (~1.9 km to the northwest), Uis Mining Village (~1.7 km to the east) and Tatamutsi (~3.4 km to the east). Individual farmsteads also surround the project area.
- Measured baseline noise levels were between 32.9 and 46.1 dBA during the day and between 25.6 and 55.2 dBA during the night.

A source inventory was developed for the project. Noise emissions or sound power levels (L_W's) for these were calculated using predictive equations for industrial machinery as per the Handbook of Acoustics, Chapter 69, by Bruce and Moritz (1998) and from Source Measurement Databases.

The source inventory, local meteorological conditions and information on topography and local land use were used to populate the noise propagation model (CadnaA, ISO 9613). The propagation of noise was calculated over an area of 9.68 km east-west by 10.02 km north-south. The area was divided into a grid matrix with a 20-m resolution and NSRs were included as discrete receptors.

Simulations indicate that exceedance of the day-time IFC guideline of 55 dBA for residential, educational, and institutional receptors will occur up to 450 m from the project site. The night-time simulated noise-levels exceed night-time IFC guidelines of 45 dBA for residential, educational, and institutional receptors up to ~1 km from the project site. The closest residential NSR is ~1.7 km east of the site.

It is recommended that general good practice measures for managing noise as set out in this report, be adopted as part of the facility's Environmental Management Plan. In the event that noise related complaints are received, short term (30-min to 24-hours in duration) ambient noise measurements should be conducted as part of investigating the complaints. The results of the measurements should be used to inform any follow up interventions.

The significance of environmental noise impacts was assessed according to the methodology adopted by ECC. The significance of project operations was found to be ***minor**.*

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1 Introduction

The Uis tin mine is a historical mine that was owned and operated by Imkor Tin, a subsidiary of Iscor South Africa. Mining commenced in 1958, and the operation was closed in 1991 (Maritz & Uludag, 2019).

The Uis Tin Mine infrastructure development commenced in 2018 on the historical Uis Tin Mine located adjacent to the Uis mining village which was developed to support the historical mine (AfriTin Mining, 2021).

AfriTin received a mandate to develop the Uis Tin Project in Namibia through two phases (AfriTin Mining, 2021):

1. Phase 1: Development of a pilot mining and processing facility, exploration drilling, and the completion of a bankable feasibility study for the final mine configuration.
2. Phase 2: Construction of the final mine configuration to mine and process 3.1 Mtpa ore to produce 5 ktpa of saleable tin concentrate.

Phase 1 will be implemented across various stages (AfriTin Mining, 2021):

- Stage I: Achieve steady-state production. The commissioning of the Phase 1 processing plant commenced in August 2019. Plant throughput has increased steadily month-on-month, although current production remains below the design capacity. Debottlenecking of the plant, combined with various other initiatives to improve availability and utilisation, support the ramp-up to the original steady-state production targets.
- **Stage II**: Increase production capacity and recovery by:
  - increasing throughput capacity by 50% from 80 tph to 120 tph, which can be achieved by modular expansion of individual circuits;
  - improving overall recovery of tin (Sn) from 60% to 70% by adding comminution and beneficiation capacity for tailings streams in the concentrator, which are currently discarded; and
  - improving overall recovery of tantalum (Ta) from 15% to 30% by optimising liberation between the tin and tantalum bearing minerals and improved magnetic separation efficiency.
- Stage III: Introduce a second by-product by adding a circuit to produce a petalite concentrate at 4% Li_2O to sell into the glass and ceramics market.
- Stage IV: Further expand tin and tantalum concentrate production by increasing average concentrator plant feed tin grade from 0.139% to 0.158% through implementation of an automated ore-sorting circuit after the first two crushing stages to reject barren pegmatite before the final stages of comminution and then concentration.

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Compliance Consultancy (ECC) to undertake a specialist environmental noise impact study for the proposed Phase 1 Fast-Tracked Stage II expansion of the Uis Tin Mine (hereafter referred to as the project).

The Phase 1 Fast-Tracked Stage II expansion includes the following changes to the process flow in various sections of the plant (AfriTin Mining, 2021):

- A secondary crusher and screen are added between the primary jaw crusher and the fines crushing section.
- A stockpile is added as a buffer between the crushing and concentrating sections.
- Water rejection capacity is increased in the Dense Medium Separation (DMS) 1 section.
- The medium circuits for DMS 2 and DMS 3 are combined to improve operability of DMS 3 and maximise tin recovery from DMS 2 floats after further liberation.
- The DMS 2 floats re-crush circuit is converted to a closed circuit by adding a classification screen in the circuit. In addition, feed is added before the roll crushers to improve operability.
- Additional spirals to re-process middlings are installed in the spiral plant.
- The product handling infrastructure is relocated, and an additional shaking table is installed to improve capacity. The existing Wilfley shaking tables are replaced with Holman tables for higher separation efficiency.

The layout for the Uis Tin Mining Project and Materials Handling and Concentrating Plant (MHCP) is provided in Figure 1 and Figure 2 respectively.

1.1 Study Objective

The main objective of the noise specialist study was to determine the potential impact on the acoustic environment and noise sensitive receptors (NSRs) as a result of the operations at the project site and to recommend suitable management and mitigation measures.

1.2 Scope of Work

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of potential NSRs from available maps and field observations.
    b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data.
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from a survey conducted for the site.
4. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Noise propagation simulations to determine environmental noise levels as a result of the project activities.
    c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist noise impact assessment report.

Figure 1: Layout of the Uis Tin Mining Project

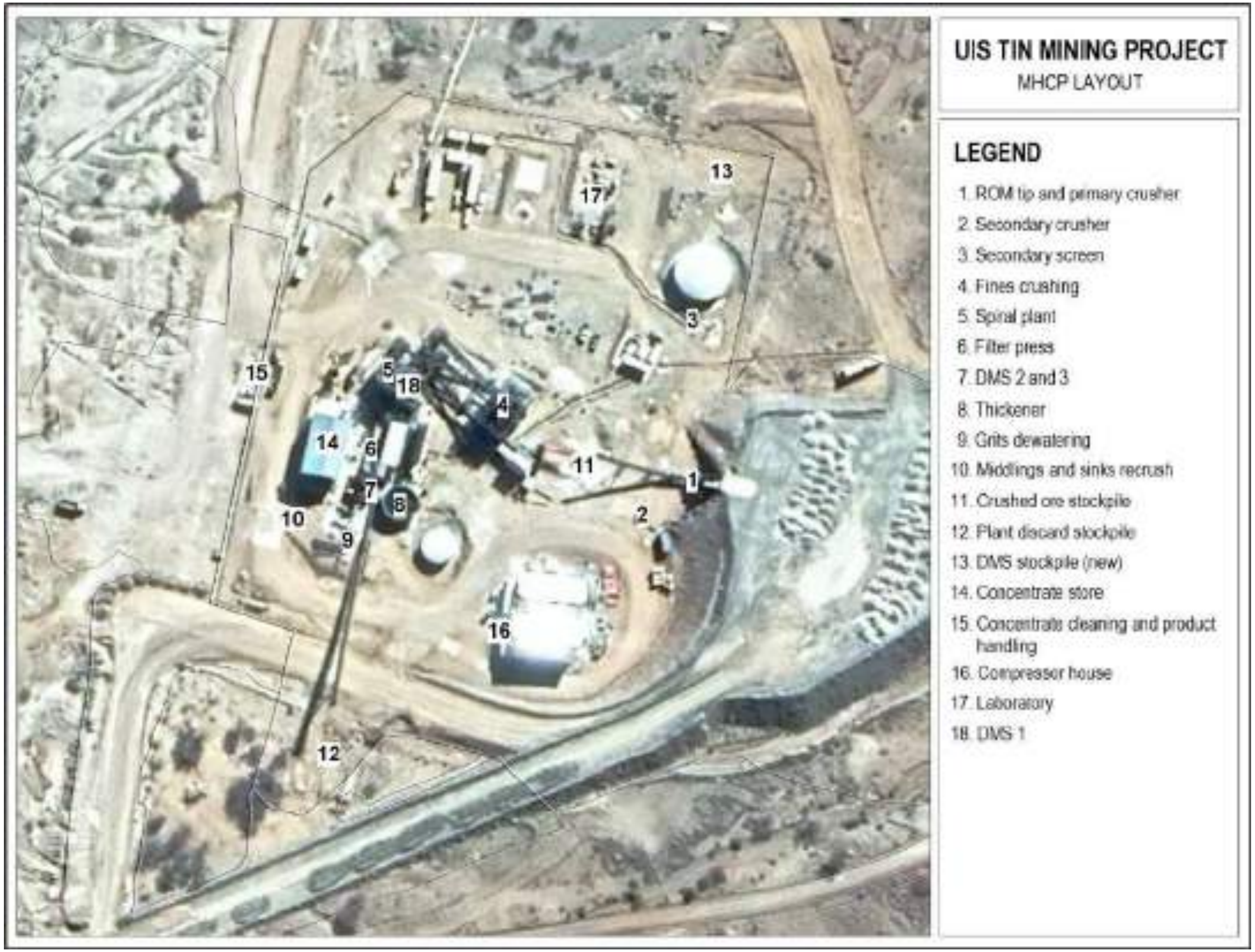


Figure 2: Layout of the Materials Handling and Concentrating Plant (MHCP)

1.3 Specialist Details

1.3.1 Specialist Details

Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

1.3.2 Competency Profile of Specialist

Reneé von Gruenewaldt is a Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP) and a member of the National Association for Clean Air (NACA).

Following the completion of her bachelor's degree in atmospheric sciences in 2000 and honours degree (with distinction) with specialisation in Environmental Analysis and Management in 2001 at the University of Pretoria, her experience in air pollution started when she joined Environmental Management Services (now Airshed Planning Professionals) in 2002. Reneé von Gruenewaldt later completed her master's degree (with distinction) in Meteorology at the University of Pretoria in 2009.

Reneé von Gruenewaldt was made partner at Airshed Planning Professionals in September 2006. Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering, and strategic air pollution impact assessment and management services and policy support to assist clients in addressing a wide variety of air quality and environmental noise related assessments.

She has experience on the various components of environmental noise assessments from 2015 to present. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to noise impacts.

A comprehensive curriculum vitae of Reneé von Gruenewaldt is provided in Appendix A.

1.4 Description of Activities from a Noise Perspective

1.4.1 Construction

Noise generating sources during construction include equipment used for activities such as land clearing, site preparation, excavation, clean-up, and landscaping.

Construction can be described or divided into distinct categories. These are earthmoving equipment, materials handling equipment, stationary equipment, impact equipment, and other types of equipment. The first three categories include machines that are powered by internal combustion engines. Machines in the latter two categories are powered pneumatically, hydraulically, or electrically. Additionally, exhaust noise tends to account for most of the noise emitted by machines in the first three categories (those that use internal combustion engines) whereas engine-related noise is usually secondary to the noise produced by the impact between impact equipment and the material on which it acts (Bugliarello, et al., 1976).

Construction and diesel mobile mining equipment generally produce noise in the lower end of the frequency spectrum. Reverse, or moving beeper alarms emit at higher frequency ranges and are often heard over long distances.

Noise generated during construction activities is highly variably since it is characterised by variations in the power expended by equipment. Besides having daily variations in activities, construction is accomplished in several different phases where each phase has a specific equipment mix depending on the work to accomplished during that phase.

1.4.2 Operation

Sound fields in an industrial setting are usually complex due to the participation of many sources: propagation through air (air-borne noise), propagation through solids (structure-borne noise), diffraction at the machinery boundaries, reflection from the floor, wall, ceiling and machinery surface, absorption on the surfaces, etc. High noise levels can therefore be present in the vicinity of operating machinery. The project will include pumps, secondary crushing, various screening facilities, conveyor activities and extraction fan. For a given machine, the sound pressure levels depend on the part of the total mechanical or electrical energy that is transformed into acoustical energy.

The project layout is provided in Figure 2.

1.4.3 Operational Hours

Project activities have been assumed to take place 24 hours per day.

1.5 Background to Environmental Noise and the Assessment Thereof

Before more details regarding the approach and methodology adopted in the assessment is given, the reader is provided with some background, definitions and conventions used in the measurement, calculation and assessment of environmental noise.

Noise is generally defined as unwanted sound transmitted through a compressible medium such as air. Sound in turn, is defined as any pressure variation that the ear can detect. Human response to noise is complex and highly variable as it is subjective rather than objective.

A direct application of linear scales (in pascal (Pa)) to the measurement and calculation of sound pressure leads to large and unwieldy numbers. As the ear responds logarithmically rather than linearly to stimuli, it is more practical to express acoustic parameters as a logarithmic ratio of the measured value to a reference value. This logarithmic ratio is called a decibel or dB. The advantage of using dB can be clearly seen in Figure 3. Here, the linear scale with its large numbers is converted into a manageable scale from 0 dB at the threshold of hearing (20 micro-pascals (μPa)) to 130 dB at the threshold of pain (~100 Pa) (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

As explained, noise is reported in dB. "dB" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure. The relationship between sound pressure and sound pressure level is illustrated in this equation.

$$L_p = 20 \cdot \log_{10}\left(\frac{p}{p_{ref}}\right)$$

Where:

L_p *is the sound pressure level in dB;*

p *is the actual sound pressure in Pa; and*

p_{ref} *is the reference sound pressure (p_{ref} in air is 20 μPa).*

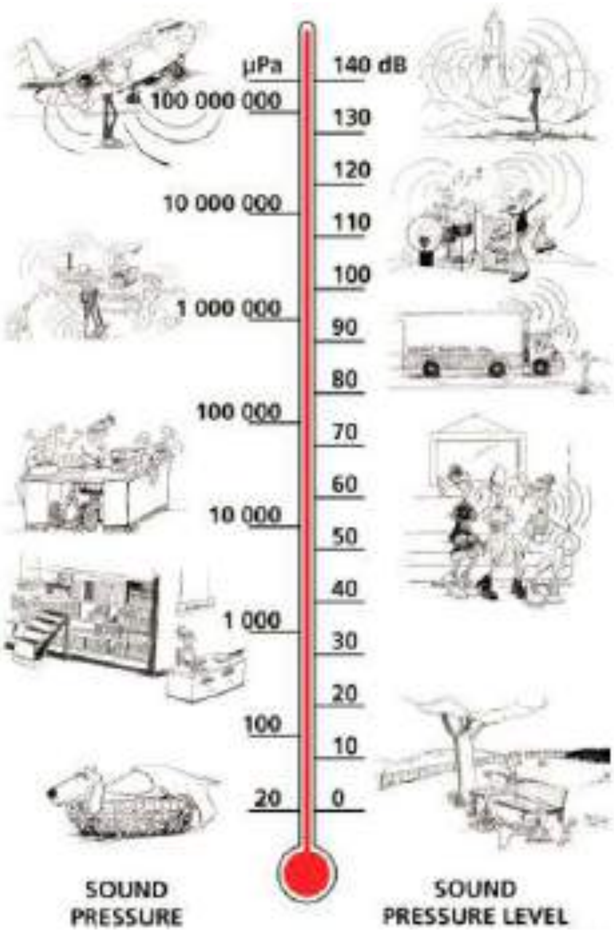


Figure 3: The decibel scale and typical noise levels (Brüel & Kjær Sound & Vibration Measurement A/S, 2000)

1.5.1 Perception of Sound

Sound has already been defined as any pressure variation that can be detected by the human ear. The number of pressure variations per second is referred to as the frequency of sound and is measured in hertz (Hz). The hearing frequency of a young, healthy person ranges between 20 Hz and 20 000 Hz.

In terms of L_P, audible sound ranges from the threshold of hearing at 0 dB to the pain threshold of 130 dB and above. Even though an increase in sound pressure level of 6 dB represents a doubling in sound pressure, an increase of 8 to 10 dB is required before the sound subjectively appears to be significantly louder. Similarly, the smallest perceptible change is about 1 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.5.2 Frequency Weighting

Since human hearing is not equally sensitive to all frequencies, a 'filter' has been developed to simulate human hearing. The 'A-weighting' filter simulates the human hearing characteristic, which is less sensitive to sounds at low frequencies than at high frequencies (Figure 4). "dBA" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units (in this case sound pressure) and have been A-weighted.

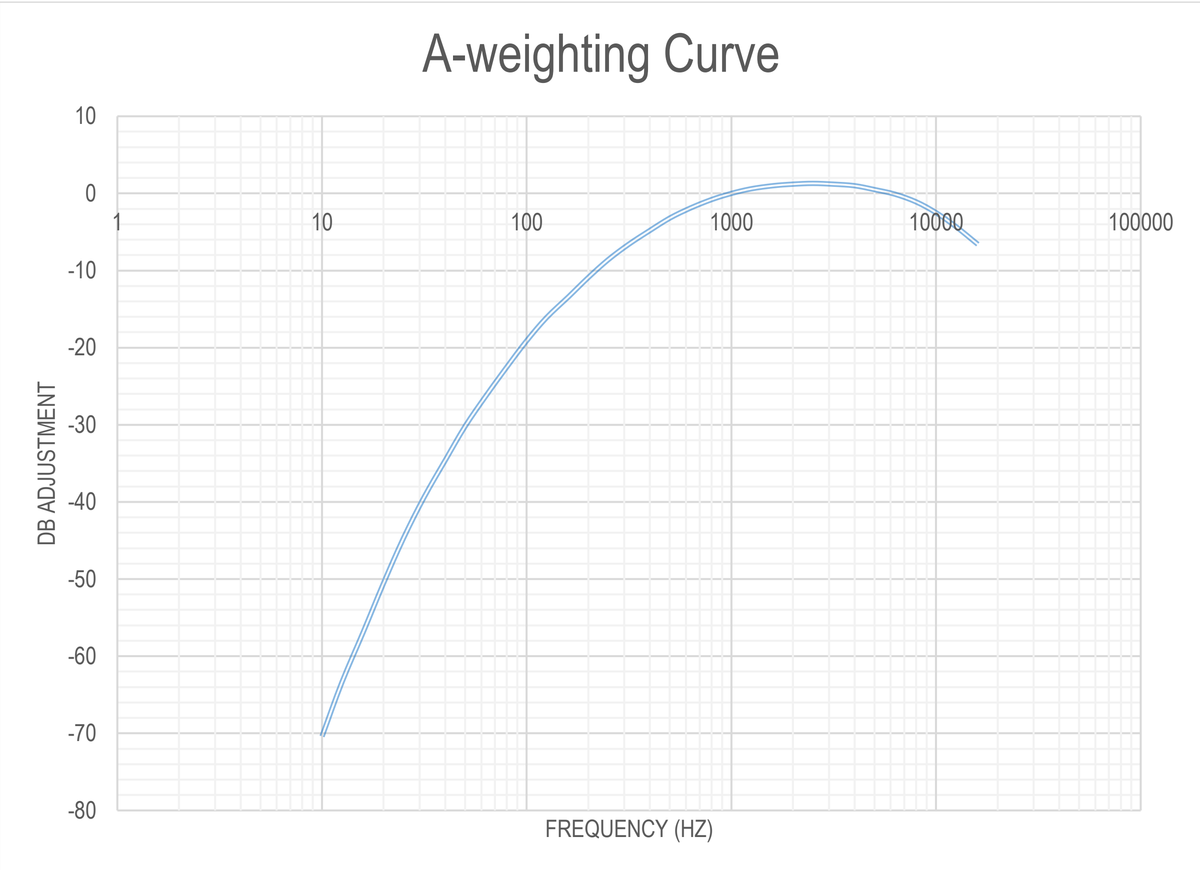


Figure 4: A-weighting curve

1.5.3 Adding Sound Pressure Levels

Since sound pressure levels are logarithmic values, the sound pressure levels as a result of two or more sources cannot simply be added together. To obtain the combined sound pressure level of a combination of sources such as those at an industrial plant, individual sound pressure levels must be converted to their linear values and added using:

$$L_{p\_combined} = 10 \cdot \log\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + 10^{\frac{L_{p3}}{10}} + \cdots 10^{\frac{L_{pi}}{10}}\right)$$

This implies that if the difference between the sound pressure levels of two sources is nil the combined sound pressure level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound pressure levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.5.4 Environmental Noise Propagation

Many factors affect the propagation of noise from source to receiver. The most important of these are:

- The type of source and its sound power (L_W);
- The distance between the source and the receiver;
- Atmospheric conditions (wind speed and direction, temperature and temperature gradient, humidity etc.);
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption; and
- Reflections.

To arrive at a representative result from either measurement or calculation, all these factors must be taken into account (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.5.5 Environmental Noise Indices

In assessing environmental noise either by measurement or calculation, reference is made to the following indices:

- **L_{Aeq} (T)** – The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).
- **L_{A90}** – The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels.
- **L_{AFmax}** – The maximum A-weighted noise level measured with the fast time weighting. It's the highest level of noise that occurred during a sampling period.
- **L_{AFmin}** – The minimum A-weighted noise level measured with the fast time weighting. It's the lowest level of noise that occurred during a sampling period.

1.6 Approach and Methodology

The assessment included a study of the legal requirements pertaining to environmental noise impacts, a study of the physical environment of the area surrounding the project and the analyses of existing noise levels in the area. The impact assessment focused on the estimation of sound power levels (L_W's) (noise 'emissions') and sound pressure levels (L_P's) (noise impacts) associated with the construction and operational phases. The findings of the assessment components informed recommendations of management measures, including mitigation and monitoring. Individual aspects of the noise impact assessment methodology are discussed in more detail below.

1.6.1 Information Review

An information requirements list was sent to ECC at the onset of the project. In response to the request, the following information was supplied:

- Georeferenced project layout;
- Process description;
- Mining schedule; and,
- Project equipment details.

1.6.2 Review of Assessment Criteria

In the absence of local guidelines and standards, this study refers to noise level guidelines published by the International Finance Corporation (IFC) in their '*General Environmental, Health, and Safety (EHS) Guidelines'* (IFC, 2007), as well as South African National Standard (SANS) 10103 (2008) '*The measurement and rating of environmental noise with respect to annoyance and to speech communication'.* The latter has been widely applied in neighbouring South Africa and is frequently used by local authorities when investigating noise complaints as it provides a useful scale for relating increased environmental noise levels to expected community responses.

1.6.3 Study of the Receiving Environment

NSRs generally include private residences, community buildings such as schools, hospitals and any publicly accessible areas outside an industrial facility's property. Potential NSRs were identified from satellite imagery (Google Earth).

The ability of the environment to attenuate noise as it travels through the air was studied by considering local meteorology, land use and terrain. Atmospheric attenuation potential was described based on modelled WRF meteorological data. Data for the period 2018 to 2020 was considered. Land-use was determined from satellite imagery (Google Earth) and site observations. Readily available terrain data was obtained from the United States Geological Survey (USGS) web site (https://earthexplorer.usgs.gov/) in January 2022. A study was made of Shuttle Radar Topography Mission (STRM) 1 arc-sec data.

1.6.4 Noise Survey

The extent of noise impacts as a result of an intruding noise depends largely on existing noise levels in an area. Higher ambient noise levels will result in less noticeable noise impacts and a smaller impact area. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels. The data from a baseline noise survey conducted between the 5th and 7th of May 2021 was studied to determine current noise levels within the area.

The survey methodology, which closely followed guidance provided by the IFC (2007) and SANS 10103 (2008), is summarised below:

- The survey was conducted by ECC under the guidance of a trained specialist.
- Sampling was carried out using a Type 1 sound level meter (SLM) that meet all appropriate International Electrotechnical Commission (IEC) standards and is subject to calibration by an accredited laboratory (Appendix C). Equipment details are included in Table 1.
- The acoustic sensitivity of the SLM was tested with a portable acoustic calibrator before and after each sampling session.
- Samples representative and sufficient for statistical analysis were taken with the use of the portable SLM capable of logging data continuously over the sampling time period.
- L_{Aleq} (T), L_{Aeq} (T); L_{AFmax}; L_{AFmin}; L_{90} and octave frequency spectra were recorded.
- The SLM was located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- SANS 10103 states that one must ensure (as far as possible) that the measurements are not affected by the residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer.
- A detailed log and record were kept. Records included site details, weather conditions during sampling and observations made regarding the acoustic environment of each site.

Table 1: Sound level meter details

Equipment	Serial Number	Purpose	Last Calibration Date
Svantek 977 sound level meter	S/N 36183	Noise sampling.	1,2 March 2021
Svantek 7052E ½" microphone	S/N 78692		
Svantek SV 12L ½" pre-amplifier	S/N 40659		
SVANTEK SV33 Class 1 Acoustic Calibrator	S/N 43170	Testing of the acoustic sensitivity before and after each daily sampling session.	2 March 2021
Kestrel 4000 Pocket Weather Tracker	S/N 559432	Determining wind speed, temperature and humidity during sampling.	Not Applicable

1.6.5 Source Inventory

To determine the change in noise impacts associated with the project, a source inventory had to be developed. A process description (AfriTin Mining, 2021), layout images and a list of equipment for the main noise sources was provided. This information was used to compile the source inventory. L_W's for these were calculated using predictive equations for industrial machinery as per the Handbook of Acoustics, Chapter 69, by Bruce and Moritz (1998).

Conveyor, crushing and screening L_W's were obtained from a Source Measurement Databases for similar operations. Values from the database are based on source measurements carried out in accordance with the procedures specified in SANS 10103.

Construction and decommissioning activities are expected to result in noise impacts similar to or less significant than impacts associated with the operational phase. A source inventory was therefore only developed for the operational phase of the project.

1.6.6 Noise Propagation Simulations

The propagation of noise from proposed activities was simulated with the DataKustic CadnaA software. Use was made of the International Organisation for Standardization's (ISO) 9613 module for outdoor noise propagation from industrial noise sources.

1.6.6.1 ISO 9613

ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favourable to propagation from sources of known sound emission. These conditions are for downwind propagation or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

The method also predicts an average A-weighted sound pressure level. The average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions. The method specified in ISO 9613 consists specifically of octave-band algorithms (with nominal mid-band frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects: geometrical divergence, atmospheric absorption, ground surface effects, reflection and obstacles. A basic representation of the model is given in the equation below:

$$L_P = L_W - \sum [K_1, K_2, K_3, K_4, K_5, K_6]$$

Where;

L_P *is the sound pressure level at the receiver;*

L_W is the sound power level of the source;
K_1 is the correction for geometrical divergence;
K_2 is the correction for atmospheric absorption;
K_3 is the correction for the effect of ground surface;
K_4 is the correction for reflection from surfaces; and
K_5 is the correction for screening by obstacles.

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources.

To apply the method of ISO 9613, several parameters need to be known with respect to the geometry of the source and of the environment, the ground surface characteristics, and the source strength in terms of octave-band sound power levels for directions relevant to the propagation.

1.6.6.2 Simulation Domain

If the dimensions of a noise source are small compared with the distance to the listener, it is called a point source. All sources were quantified as point sources or areas/lines represented by point sources. The sound energy from a point source spreads out spherically, so that the sound pressure level is the same for all points at the same distance from the source and decreases by 6 dB per doubling of distance. This holds true until ground and air attenuation noticeably affect the level. The impact of an intruding industrial noise on the environment will therefore rarely extend over more than 5 km from the source and is therefore always considered “local” in extent.

The propagation of noise was calculated over an area of 9.68 km east-west by 10.02 km north-south and encompasses the Uis Tin Mine. The area was divided into a grid matrix with a 20 m resolution. The model was set to calculate L_P’s at each grid intercept point at a height of 1.5 m above ground level.

1.6.7 Presentation of Results

Results are presented in tabular and isopleth form. An isopleth is a line on a map connecting points at which a given variable (in this case sound pressure, L_P) has a specified constant value. This is analogous to contour lines on a map showing terrain elevation. In the assessment of environmental noise, isopleths present lines of constant noise level as a function of distance.

Simulated noise levels were assessed according to guidelines published by the IFC. To assess annoyance at nearby places of residence, the increase in noise levels above the baseline at NSRs were calculated and compared to guidelines published in SANS 10103.

1.6.8 Recommendations of Management and Mitigation

The findings of the noise specialist study informed the recommendation of suitable noise management and mitigation measures.

1.6.9 Impact Significance Assessment

The significance of environmental noise impacts was assessed according to the methodology developed by ECC.

1.7 Management of Uncertainties

The following limitations and assumptions should be noted:

- The mitigating effect of buildings and infrastructure acting as acoustic barriers were not taken into account providing a conservative assessment of the noise impacts off-site.
- The quantification of sources of noise was limited to the operational phase of the project. Construction and closure phase activities are expected to be similar or less significant and its impacts only assessed qualitatively. Noise impacts will cease post-closure.
- All activities were assumed to be 24 hours per day, 7 days per week.
- Although other existing sources of noise within the area were identified, such sources were not quantified but were taken into account during the survey.
- Only potential noise impacts due to the MHCP Phase 1 Fast-Tracked Stage II expansion was taken into account for the assessment. It was assumed that day- and night-time mining activities were taking place during the baseline noise survey as these activities were audible during the measurements. Mining activities were therefore not taken into consideration for the attenuation modelling (to account for changes from baseline activities) for the project.
- Although the noise impact due to equipment alarms are recognised, it is not considered as part of the environmental noise impact assessment as these signals are used for warning purposes which are excluded in impact assessments.
- The environmental noise assessment focuses on the evaluation of impacts on humans.

2 Legal Requirements and Noise Level Guidelines

The IFC best practice guidelines were adopted in the absence of Namibian legislation.

2.1 International Finance Corporation Guidelines on Environmental Noise

The IFC General Environmental Health and Safety Guidelines on noise address impacts of noise beyond the property boundary of the facility under consideration and provides noise level guidelines.

The IFC states that noise impacts **should not exceed the levels presented in Table 2**, or result in a maximum **increase above background levels of 3 dBA** at the nearest receptor location off-site (IFC, 2007). For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. Δ = 3 dBA is, therefore, a useful significance indicator for a noise impact.

It is further important to note that the IFC noise level guidelines for residential, institutional and educational receptors correspond with the SANS 10103 guidelines for urban districts.

Table 2: IFC noise level guidelines

Area	One Hour L_{Aeq} (dBA) 07:00 to 22:00	One Hour L_{Aeq} (dBA) 22:00 to 07:00
Industrial receptors	70	70
Residential, institutional and educational receptors	55	45

2.2 South African National Standards

In South Africa, provision is made for the regulation of noise under the National Environmental Management Air Quality Act (NEMAQA) (Act. 39 of 2004) but legally enforceable environmental noise limits have yet to be set. It is believed that when published, national criteria will make extensive reference to the South African Bureau of Standards (SABS) standard SANS 10103 (2008) *'The measurement and rating of environmental noise with respect to annoyance and to speech communication'.* This standard has been widely applied in South Africa and is frequently used by local authorities when investigating noise complaints. The standard is also fully aligned with the WHO guidelines for Community Noise (WHO, 1999). It should be noted that the values given in Table 3 are typical rating levels that it is recommended should not be exceeded outdoors in the different districts specified. Outdoor ambient noise exceeding these levels will be annoying to the community.

Table 3: Typical rating levels for outdoor noise

Type of district	Equivalent Continuous Rating Level ($L_{Req,T}$) for Outdoor Noise		
	Day/night $L_{R,dn}$[(c)] (dBA)	Day-time $L_{Req,d}$[(a)] (dBA)	Night-time $L_{Req,n}$[(b)] (dBA)
Rural districts	45	45	35
Suburban districts with little road traffic	50	50	40
Urban districts	55	55	45
Urban districts with one or more of the following: business premises; and main roads.	60	60	50
Central business districts	65	65	55
Industrial districts	70	70	60

Notes

(a) $L_{Req,d}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.

(b) $L_{Req,n}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.

(c) $L_{R,dn}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.

SANS 10103 also provides a useful guideline for estimating community response to an increase in the general ambient noise level caused by intruding noise. If Δ is the increase in noise level, the following criteria are of relevance:

- "$\Delta \leq 0$ dB: There will be no community reaction;
- 0 dB < $\Delta \leq$ 10 dB: There will be 'little' reaction with 'sporadic' complaints;
- 5 dB < $\Delta \leq$ 15 dB: There will be a 'medium' reaction with 'widespread complaints'. Δ = 10 dB is subjectively perceived as a doubling in the loudness of the noise;
- 10 dB < $\Delta \leq$ 20 dB: There will be a 'strong' reaction with 'threats of community action'; and
- 15 dB < Δ: There will be a 'very strong' reaction with 'vigorous community action'.

The categories of community response overlap because the response of a community does not occur as a stepwise function, but rather as a gradual change.

3 Description of the Receiving Environment

This chapter provides details of the receiving acoustic environment which is described in terms of:

- Local NSRs;
- The local environmental noise propagation and attenuation potential; and
- Current noise levels and the existing acoustic climate.

3.1 Noise Sensitive Receptors

Noise sensitive receptors generally include places of residence and areas where members of the public may be affected by noise generated by mining, processing, and transport activities.

As mentioned in Section 1.6.6.2, the impact of an intruding industrial/mining noise on the environment rarely extends over more than 5 km from the source. The closest residential developments to the proposed project consist of Uis (~1.9 km to the northwest), Uis Mining Village (~1.7 km to the east) and Tatamutsi (~3.4 km to the east). Individual farmsteads also surround the project area (Figure 1 as identified from Google Earth).

3.2 Environmental Noise Propagation and Attenuation Potential

3.2.1 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to their role in the propagation on noise from a source to receiver (Section 1.5.4). The main meteorological parameters affecting the propagation of noise include wind speed, wind direction and temperature. These along with other parameters such as relative humidity, air pressure, solar radiation and cloud cover affect the stability of the atmosphere and the ability of the atmosphere to absorb sound energy.

Wind speed increases with altitude. This results in the ‘bending’ of the path of sound to ‘focus’ it on the downwind side and creating a ‘shadow’ on the upwind side of the source. Depending on the wind speed, the downwind level may increase by a few dB but the upwind level can drop by more than 20 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). It should be noted that at wind speeds of more than 5 m/s, ambient noise levels are mostly dominated by wind generated noise.

Data from WRF data for the period 2018 to 2020 was used for the assessment (Figure 6). The modelled data set indicates wind flow primarily from the south southwest for day-time. At night, wind shifted to be mostly from the southern sector. On average, noise impacts are expected to be slightly more notable north northeast during the day and north of the project activities during the night.

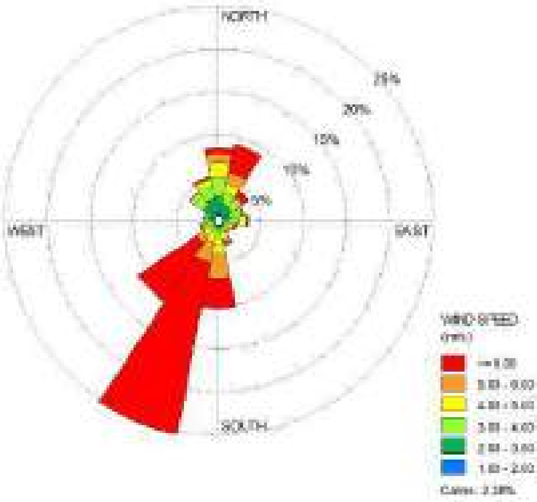
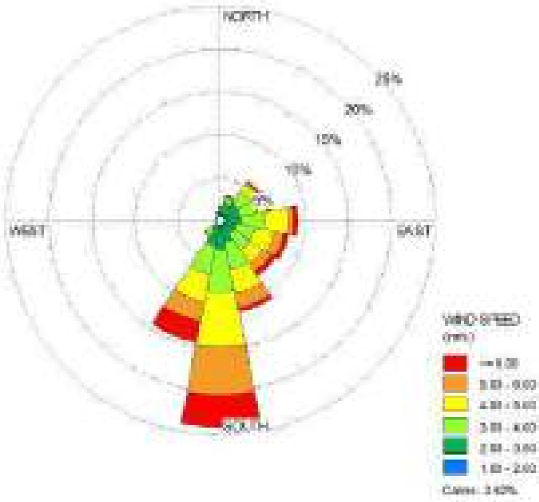
Day-time wind field (07:00 to 22:00)	Night-time wind field (22:00 to 07:00)
	

Figure 5: Wind rose for WRF data, 1 January 2018 to 31 December 2020

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On a clear night, temperatures may increase with altitude thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more notable during the night.

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On a clear night, temperatures may increase with altitude thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more notable during the night (Figure 6). CadnaA requires the definition of both temperature and humidity. An average temperature of 22°C and a humidity of 34% (as obtained from the WRF data for the period 2018-2020) were applied in simulations.

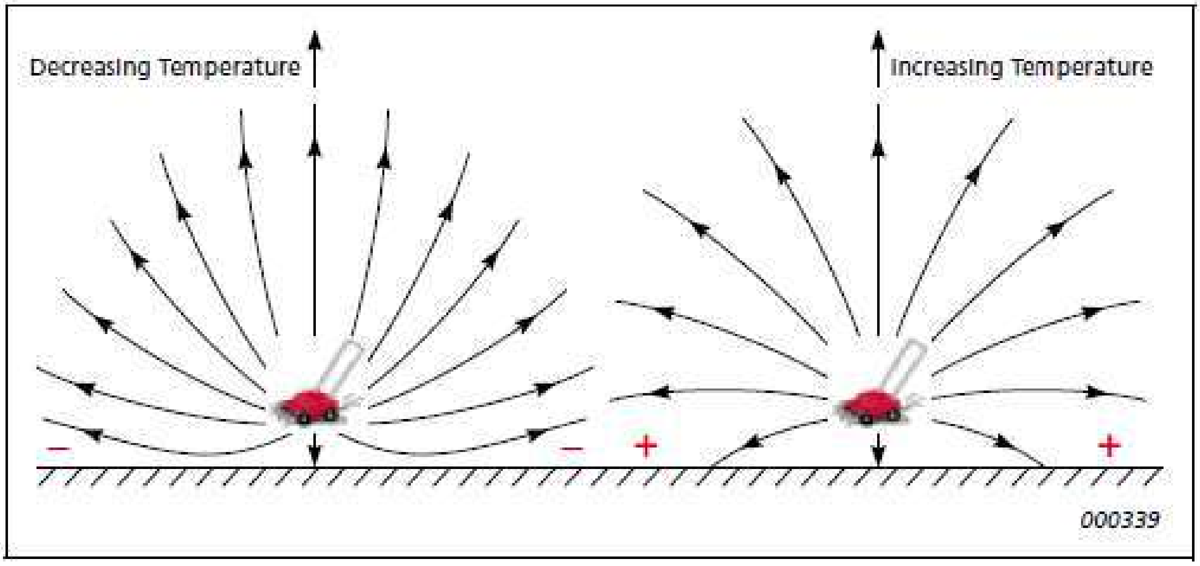


Figure 6: Bending the path of sound during typical day time conditions (image provided on the left) and night-time conditions (image provided on the right)

3.2.2 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (i.e. natural terrain, installed acoustic barrier, building) feature depends on two factors namely the path difference of a sound wave as it travels over the barrier compared with direct transmission to the receiver and the frequency content of the noise (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Readily available terrain data was obtained from the United States Geological Survey (USGS) web site (https://earthexplorer.usgs.gov/) in January 2022. A study was made of Shuttle Radar Topography Mission (STRM) 1 arc-sec data.

Sound reflected by the ground interferes with the directly propagated sound. The effect of the ground is different for acoustically hard (e.g., concrete or water), soft (e.g., grass, trees or vegetation) and mixed surfaces. Ground attenuation is often calculated in frequency bands to take into account the frequency content of the noise source and the type of ground between the source and the receiver (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Based on the study area, ground cover was found to be acoustically reflecting.

3.3 Baseline Noise Levels

Survey sites were selected after careful consideration of project activities, accessibility, potential noise sensitive receptors, and safety restrictions. A total of six survey sites were selected. The location of the noise survey sites is provided in Figure 4. Photographs of the sites are included in Appendix E.

Survey results for the campaign undertaken on the 5th to the 7th of May 2021 are summarised in Table 4 and for comparison purposes, visually presented in Figure 8 (day-time results) and Figure 9 (night-time results).

For detailed time-series, frequency spectra and statistical results, the reader is referred to Appendix D.

Figure 7: Noise sampling locations within the study area

Table 4: Project baseline environmental noise survey results summary

Sampling point	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
Description	Located in Uis close to townhouse.		Near a dump site and repair house.		Located close to community.		Area is surrounded by small hills made out of rocks.		Close to small settlement.		Close to an abandoned homestead.	
Coordinates	21.21916°S; 14.87049°E		21.23076°S; 14.90026°E		21.22934°S; 14.91835°E		21.23301°S; 14.854302°E		21.27301°S; 14.85106°E		21.26667°S; 14.91030°E	
Time of day	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Start date and time	06/05/2021 14:39	06/05/2021 04:38	06/05/2021 15:24	06/05/2021 05:16	06/05/2021 12:54	06/05/2021 06:19	05/05/2021 16:18	07/05/2021 05:53	05/05/2021 15:26	07/05/2021 06:29	06/05/2021 12:01	07/05/2021 05:09
Duration	00:31:30	00:21:03	00:32:10	00:20:46	00:30:37	00:20:25	00:32:22	00:21:46	00:31:19	00:20:36	00:30:57	00:20:22
Visual and acoustic observations	Birds, insects, vehicles and mining activities in the distance contribute to the acoustic sources.		Community activities and mining activities in the distance contribute to the acoustic sources.		Community activities, chickens, vehicles and excavators contribute to the acoustic sources. Distant mining activities are audible at night.		Vehicles, tractor, birds and insects contribute to the acoustic sources. Distant operations in town and dogs barking in the area audible at night.		Community activities and birds contribute to the acoustic sources during the day. Chickens and mining operations were audible during the night.		Birds and distant air traffic contribute to the acoustic sources during the day with distant mining activities contributing to the acoustic sources during the night.	
General weather conditions	Wind speeds of 1.9 m/s from the north east 28°C 80% cloud cover	Wind speeds of 1.2 m/s from the north east 22°C 70% cloud cover	Wind speeds of 0.7 m/s from the north east 28°C 70% cloud cover	Wind speeds of 1.1 m/s from the east 22°C 70% cloud cover	Wind speeds of 1.5 m/s from the east 27°C 80% cloud cover	Wind speeds of 0.6 m/s from the east 21°C 60% cloud cover	Wind speeds of 0.3 m/s from the north east 33°C 60% cloud cover	Wind speeds of 0.5 m/s from the north east 21°C 60% cloud cover	Wind speeds of 1.4 m/s from the east 31°C 60% cloud cover	Wind speeds of 0.4 m/s from the east 22°C 60% cloud cover	Wind speeds of 2.8 m/s from the north east 25°C 70% cloud cover	Wind speeds of 1.4 m/s from the north east 19°C 60% cloud cover
LAFmin (dBA)	27.0	33.6	25.6	20.4	27.0	19.5	19.3	18.2	19.5	18.9	25.1	18.8
LAFmax (dBA)	55.6	51.0	55.7	78.4	69.2	60.5	64.3	55.0	56.1	66.2	64.4	55.5
LAIeq (dBA)	50.3	52.1	54.7	59.0	52.6	57.0	57.3	51.2	50.2	52.3	51.7	50.8
LA90 (dBA)	30.6	36.0	30.4	22.5	34.1	21.8	21.6	18.2	21.3	19.9	29.1	19.9
LAeq (dBA)	39.2	44.1	37.1	**55.2**	46.1	33.2	39.4	25.6	32.9	**47.5**	38.9	26.5

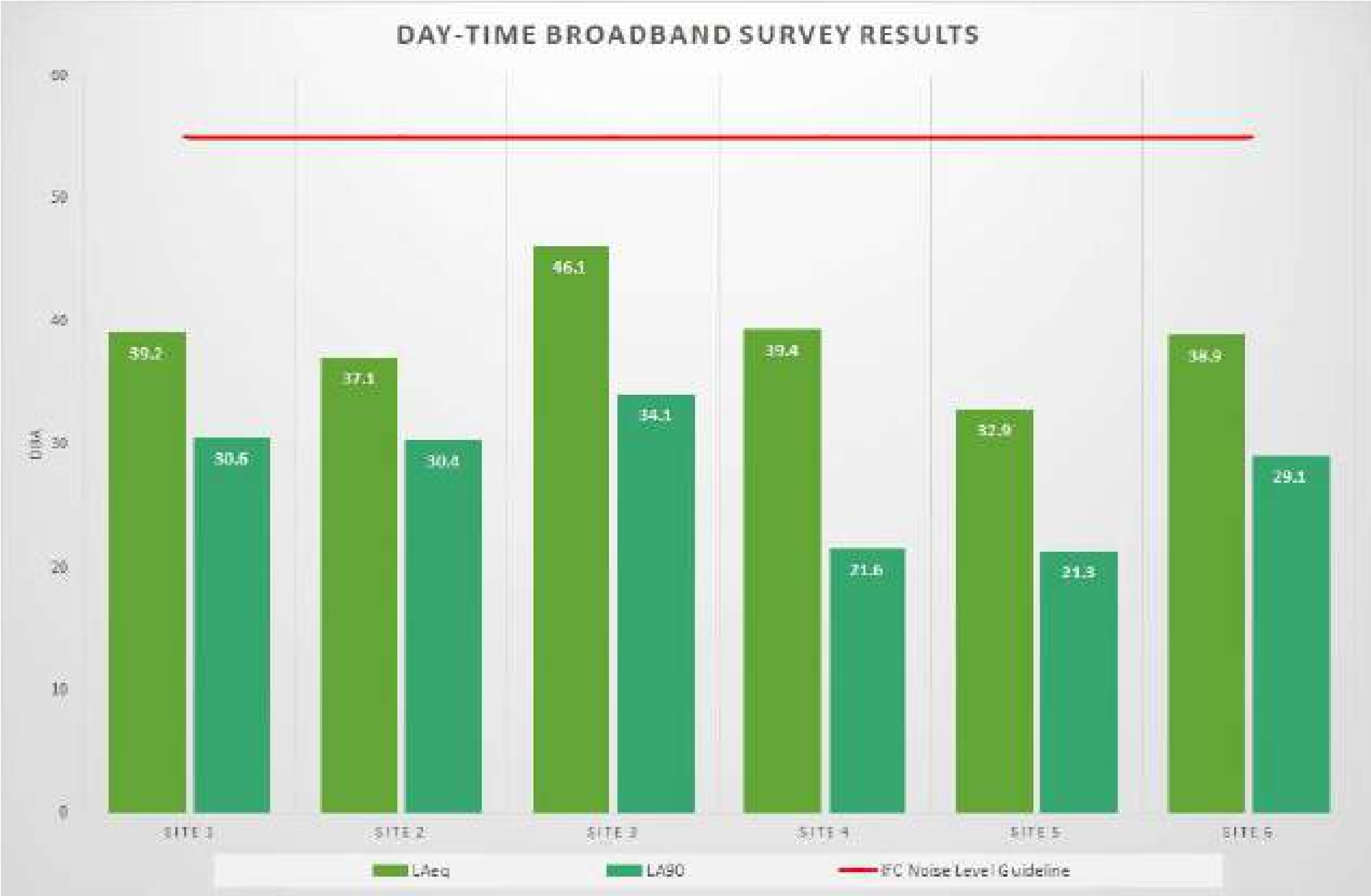


Figure 8: Day-time broadband survey results

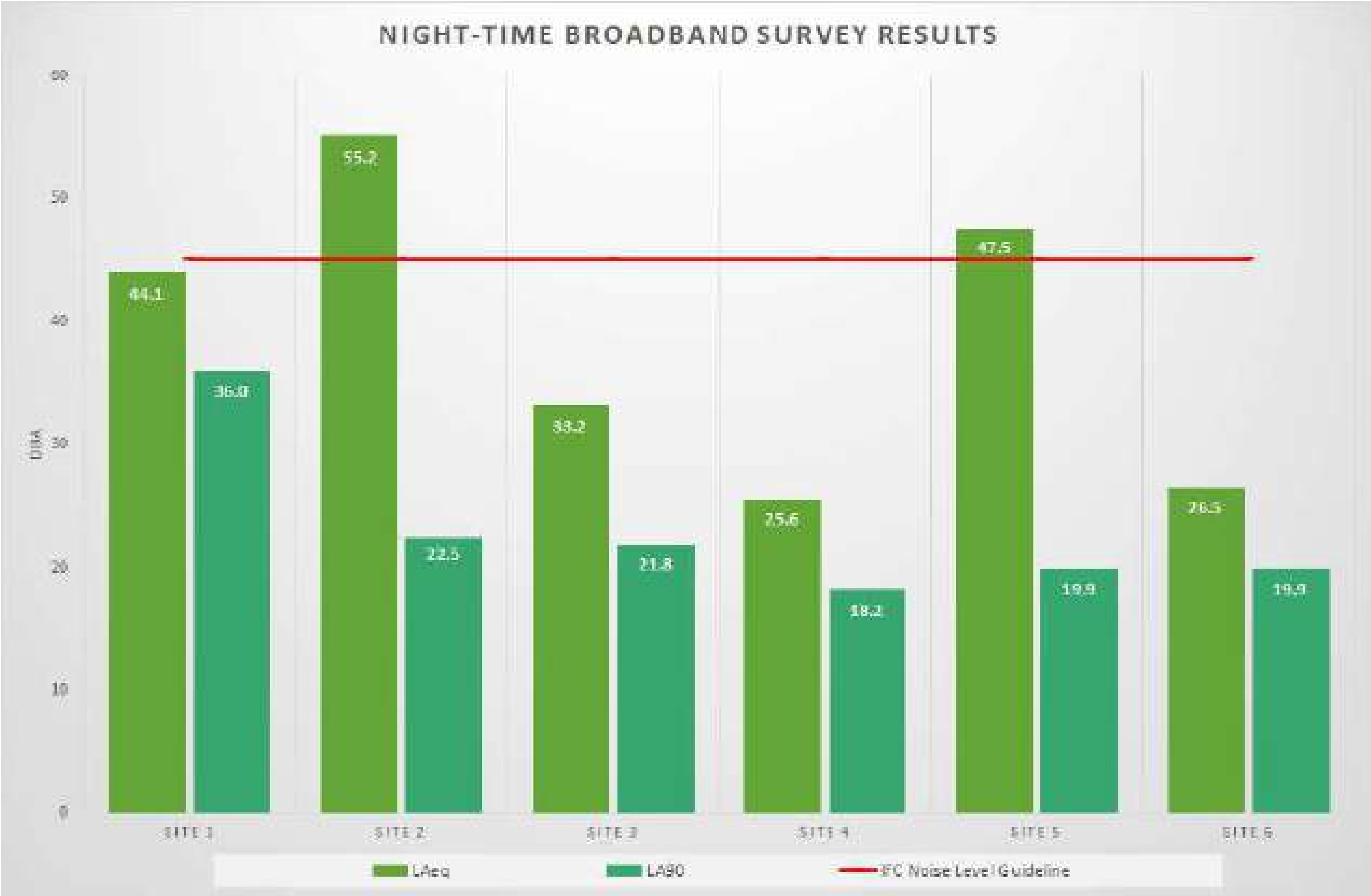


Figure 9: Night-time broadband survey results

4 Impact Assessment

The process description, noise source inventory, noise propagation modelling and results are discussed in Section 4.2, Section 4.2 and Section 4.3 respectively.

4.1 Process Description

A number of changes and upgrades are required in most areas of the MHCP and are discussed per functional area (AfriTin Mining, 2021).

4.1.1 Comminution – Dry Crushing and Screening

4.1.1.1 New Closed-Loop Secondary Crushing and Screening System

Simulations showed that the comminution system capacity can be improved by adding a closed-loop secondary crushing and screening system between the primary crusher and the existing crushed ore stockpile (Figure 10). This will introduce the following benefits:

- Correct-sized material will be removed before the existing buffer stockpile, thereby creating more capacity in the existing fines cone crushing system (currently secondary to quaternary crushers). Re-crushing of correct-sized material will also be prevented, thereby avoiding over-crushing and fines generation.
- The particle size distribution on the existing buffer stockpile will be reduced due to the removal of the correct-sized material.
- Crushing capacity will be increased through the new secondary crusher and the introduction of an additional buffer in the form of a new DMS feed stockpile that will be fed from the undersize of the new secondary screen.
- The removal of the fines in the new secondary screen unit should reduce the dust generation on this stockpile. A tunnel ventilation fan will be added in the crushed ore stockpile tunnel by a CI project.

An Osborn Crusher module and Osborn Screen module that are available were pre-selected (to reduce engineering design and supply times) and this guided the layout of the secondary crushing and screening circuit. The new closed-loop secondary crusher and screen system will have the following features:

- The discharge from the Vibrating Grizzly Feeder (VGF) and jaw crusher is collected onto conveyor CV-001. CV-001 will be modified to feed onto the new screen feed conveyor CV-025. Conveyor CV-025 will have a self-cleaning belt magnet to remove tramp metal.
- A new modular Osborn double-deck screening unit will be installed.
- The screen top deck will feed the new secondary crusher with conveyor CV-028. Discharge from the secondary crusher is transferred with a new conveyor CV-007 back onto CV-025 to be screened again.
- The bottom deck will feed the existing crushed ore stockpile via conveyors CV-027 and CV-002. Conveyor CV-002 will be 3 m higher to fit the new conveyor arrangement.
- The underpan will feed the new DMS feed stockpile via conveyors CV-026 and CV-024.
- The new Osborn secondary cone crusher module consists of an Osborn 44SBS type H cone crusher, with a 9 m^3 feed bin and vibrating feeder. This crusher is equipped with a combined lubrication and

hydraulic unit with oil cooling, allowing for hydraulic adjustment for release of tramp material, gap adjustment, and unscrewing of the bowl.

- A dust scrubbing system will be installed to extract dust from both the existing primary jaw crusher and the new secondary crusher and screen.

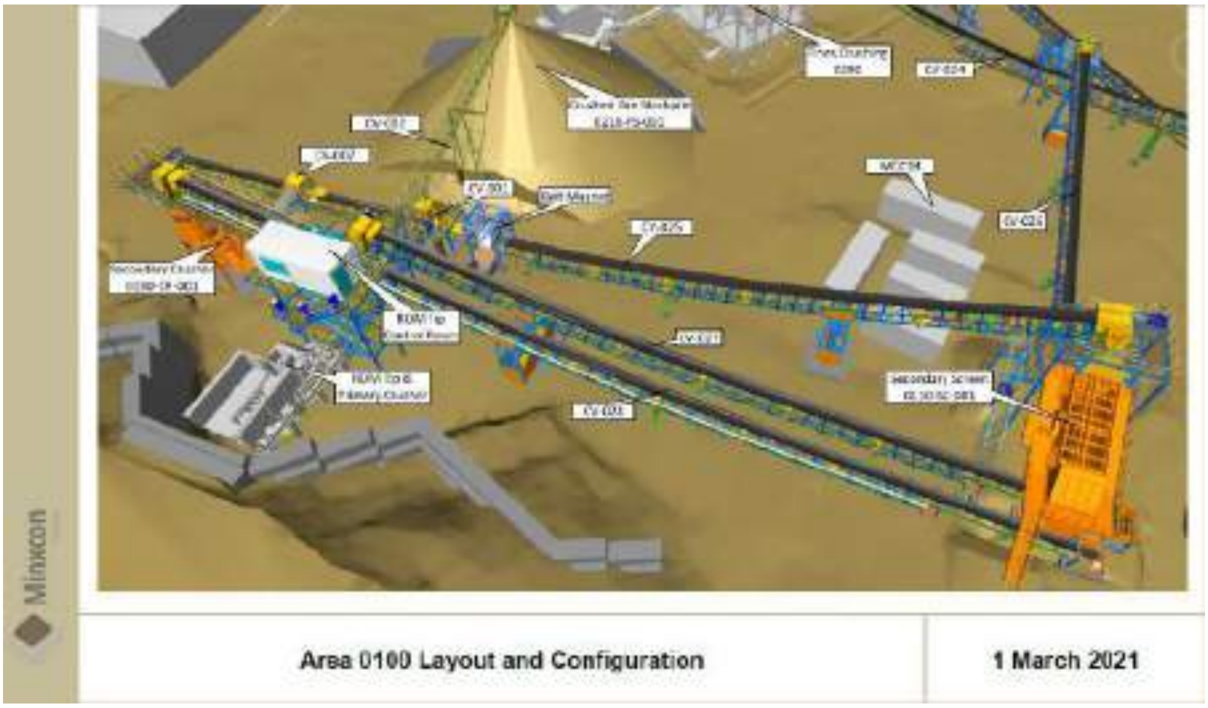


Figure 10: Area 0100 Layout and Configuration

4.1.1.2 Fines Crushing 0200

The only changes to be made in area 0200 are:

- Shorten CV-012 to feed onto new CV-024; and
- Replace conveyor CV-014 with a wider (for the increased capacity) and longer conveyor to receive material from stockpile extraction conveyor CV-029.

4.1.1.3 New DMS Feed Stockpile 0300

Limited DMS 1 feed bin capacity results in difficult feed control to the DMS 1 feed preparation screen. A new DMS feed stockpile will be constructed to combine all crushed ore, before feeding the DMS 1 plant (Figure 11).

Conveyor CV-024 feeds the new DMS feed stockpile. The secondary screen underflow reports to conveyor CV-026 and will be combined with the fines crushing underflow on conveyor CV-024. This will create additional buffer capacity between the comminution system and the concentrator and will be the sole feed source to DMS 1. During maintenance of the existing Area 0200 crushing system, DMS 1 can still be fed at full rate from the DMS feed stockpile.

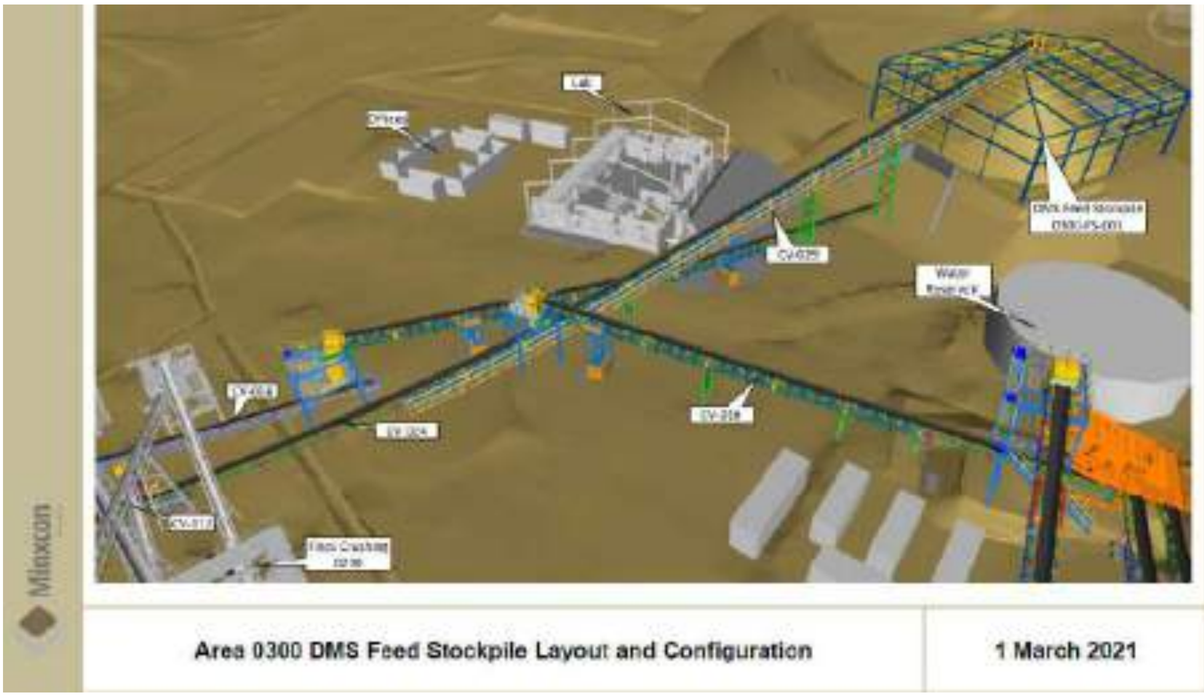


Figure 11: Area 0300 DMS Feed Stockpile Layout and Configuration

Bulk flow tests and a functional design were done for the DMS stockpile. Based on the functional design recommendations, a horizontal above-ground tunnel was designed. There will be three withdrawal points, for controlled feed with variable-speed belt feeders onto a new conveyor CV-029 feeding into a small surge bin (on the extended tail of existing DMS 1 feed conveyor CV-014). Initially only one belt feeder will be installed. A new VSD control on the replaced wider CV-014 will allow for controlled feed to the DMS 1 feed preparation screen. A terrace will be constructed around the stockpile tunnel to form a base for a square enclosed building. The tunnel will be equipped with lights and a second escape route.

This stockpile will generate wind-borne dust when dropping from the conveyor head chute onto the stockpile and must therefore be enclosed. Maintenance doors will allow access to the stockpile and the withdrawal chutes and liners (installed from the top).

4.1.2 Concentrator

4.1.2.1 DMS 1 Circuit

The DMS 1 feed is split into two streams on the preparation screen: the DMS 1 pre-concentration stream and spiral plant stream. The Phase 1 plant worked with an aperture of 0.5 mm to 0.63 mm as the design basis. This aperture will be increased to 1 mm for the increased capacity required for a 0.85 Mtpa plant. The underflow of the prep screen increases, and the DMS 1 stream increases based on this split. DMS 1 was originally designed for a high variability in the fines circuit, but this is currently reduced by managing the PSD of the plant feed prior to feeding the plant. A second pipe densifier will be added to run in parallel with the existing unit and can fit into the slot allowed for in the current plant.

Only the DMS 1 plant is affected by the increased feed rate. The DMS 2 and DMS 3 circuits are not affected by this change, because DMS 1 is controlled to keep the DMS 2 plant at a steady feed rate by changing the cut point of the cyclones.

4.1.2.2 DMS 2 and DMS 3 Circuits

DMS 3 will be reintroduced into the circuit, by combining the DMS 2 and 3 medium circuits and installing a new DMS 3 prep screen as well as a new drain and rinse screen (Figure 12).

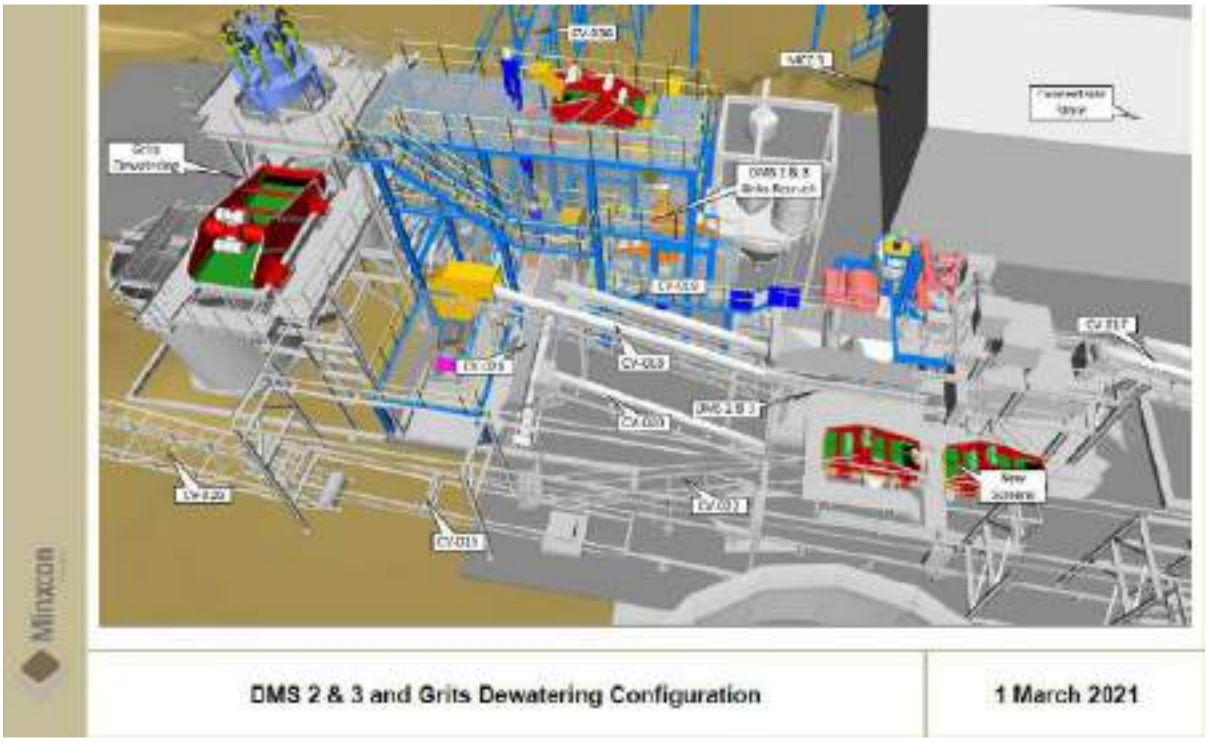


Figure 12: DMS 2 & 3 and Grits Dewatering Configuration

4.1.2.3 Roll Crushers and Ancillary Circuits

This circuit requires a redesign to improve crusher performance and availability (Figure 13). The existing four conveyors (CV-018, 019, 020 and 021) are maintained. A new middlings re-crusher facility is included to provide buffering and feed rate control. A screen (0350-SC-001) is used to control the minimum size of particles to DMS 3 and the spiral plant.

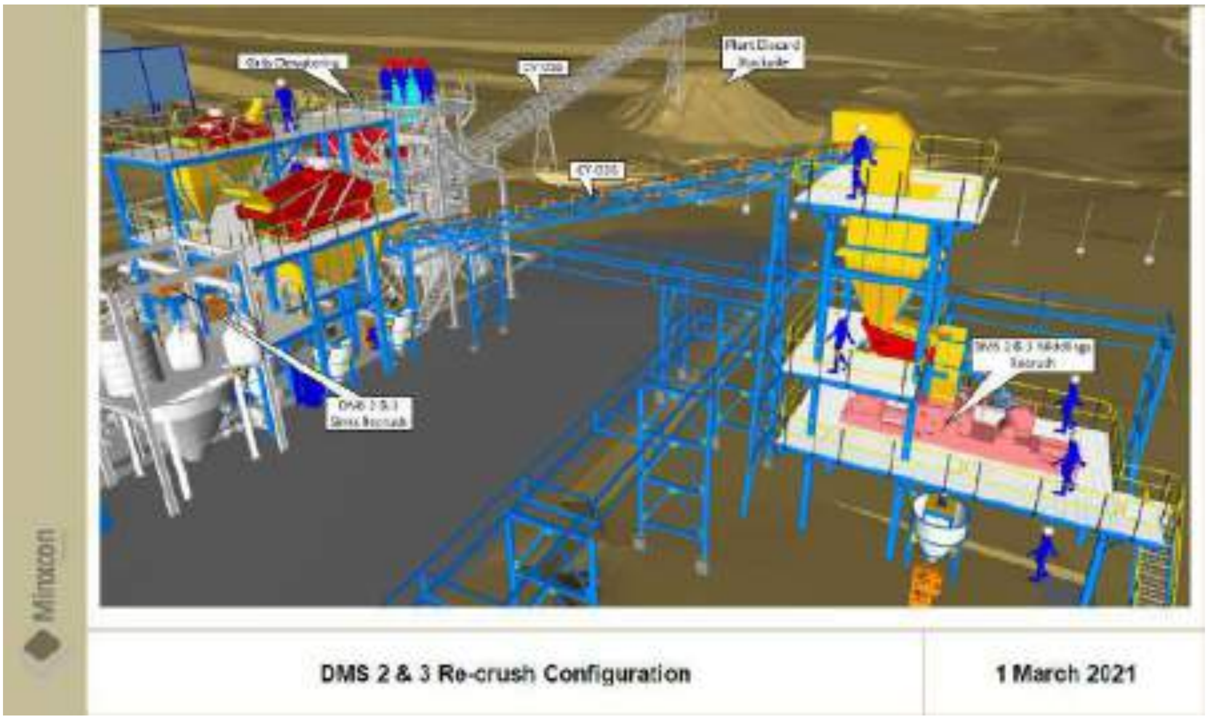


Figure 13: DMS 2 & 3 Re-crush Configuration

A second structure houses the sink crusher circuit and the screen 0350-SC-001. The order between screen and crusher is reversed in this application to prevent over crushing of the sized ore. An additional crusher is added to reduce the reduction ratio. The rest of the system is like the middlings crusher circuit, but on a smaller scale. Both circuits have buffer tanks to prevent settling and provide buffer capacity.

4.1.2.4 Spiral Plant

The spiral plant feed into the rougher spirals is fed from two sources: desliming cyclone 1 cluster and the new desliming cyclone 2 cluster. A new distributor 0440-DI-003 for the middlings spirals will be added.

The spiral concentrate will be collected in a new tank 0440-TK-005, which replaces the original unit and has limited buffer capacity for smoothing. The concentrate will then be transferred with jet pump 0440-PJ-001 at the required density to cleaning table circuit feed buffer tank 0500-TK-001.

4.1.3 Concentrate Handling

The Phase 1 concentrate handling circuit was limited to two Wilfley tables located on the top floor of DMS 1. The original design utilised a pumped layout to the top level and a gravity flow down through the magnetic circuit. This did not provide the desired result, and a new plant layout has been designed with the focus on the mine's specific material and the settling properties of the slurry, in conjunction with equipment feed densities and steady-state volume requirements. The entire concentrate cleaning circuit has been redesigned and will be relocated to the new concentrate handling area.

4.1.3.1 Cleaning Tables Circuit

The plant design philosophy utilised constant density tanks to increase density in dilute streams where required (Figure 14). This allows for the control of density at the setpoint, and the water recovered is used for the wash-water on the tables to limit the possibility of product losses. Using this philosophy, the slurry from the DMS 2 and 3 sinks is dewatered in the buffer tank (1-hour storage capacity). The spiral concentrate is pumped at the correct density to its own buffer tank (½-hour storage capacity).

Individual pump streams are fed to the Holman cleaning tables, mounted on a concrete foundation, at set volumes and density for optimum recovery. The concentrate, middlings and tails streams are collected for the DMS cleaning table and scavenger table double-deck installation and are transferred to the double-deck spiral tables collection tanks per table grouping and then pumped to those specific streams for the plant for further processing.

Figure 14: Concentrate Cleaning and Product Handling Configuration

4.1.3.2 Scavenger Tables Circuit

The middlings are combined in two tanks in series, with a combined buffer capacity of one hour, and then pumped to the top deck of the DMS cleaning table and scavenger table set for the scavenging of the middlings. The middlings and tailings streams are combined to be discarded. The concentrate is combined with the concentrate from other tables.

4.1.3.3 Concentrate Dewatering Circuit

The final Sn concentrate slurry is pumped to a buffer tank (24-hour storage capacity). This slurry is filtered in a plate and frame filter with an air pressing cycle, before being bagged.

4.1.4 Discard Dewatering and Disposal

4.1.4.1 Thickener

The existing thickener will remain as is, with the thickener discharge pump feeding the discard filter press.

4.1.4.2 Discard Filter Press System

The existing discard filter press will remain in its current position and configuration and will discharge dried filter cakes onto discard conveyor CV-015.

4.1.4.3 Process Water Supply and Reticulation

The current process water flow will be increased to accommodate the increased water demand.

The largest water demand occurs at start-up of the plant, when the facility is run on water only, supplied by pump 0630-PU-003 with a pressure controller at 6 Bar pressure. This demand is reduced with the feeding of ore into the plant.

The main process water line is reticulated on the pipe gantry to all the process areas. The water is controlled into tanks using modulating valves, knife gate valves with orifice plates, and float valves.

A makeup water line will provide water to the flocculant plant and the two scrubbers in areas 0110 and 0300. Further makeup water will be added to the process water tank from 0010-PU-009.

4.2 Noise Sources and Sound Power Levels

The complete source inventory and octave band frequency spectra L_W's are included in Table 5. The directivity of stack source for the primary and secondary scrubber is provided in Table 6.

Table 5: Octave band frequency spectra L_W's

Plant Section	Equipment	Type	L_W octave band frequency spectra (dB)								L_W (dB)	L_{WA} (dBA)	Source
			63	125	250	500	1000	2000	4000	8000			
Secondary crusher	Secondary crusher	L_W	113.3	115.4	119.3	123.9	122.8	117.6	110.3		128.1	126.1	L_W Database
	Secondary screen	L_W	115.0	109.7	105.3	104.2	103.5	103.1	99.9		117.2	109.1	L_W Database
	Conveyor transfer (x5)	L_W	107.4	105.7	106.2	107.5	105.5	101.7	97.2		113.9	109.8	L_W Database
	Conveyor belt (x5)	L_W"	67.0	61.0	65.0	66.0	64.0	52.0	40.0		72.1	67.1	L_W Database
	Secondary crushing sump pump	L_W	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
	Dust collection fan: primary and secondary crusher	L_W	95.2	97.2	96.2	95.2	95.2	91.2	87.2	80.2	103.3	99.0	L_W Predictions (Bruce & Moritz, 1998)
Area 0300 (stockpile area enclosed)	Conveyor transfer	L_W	107.4	105.7	106.2	107.5	105.5	101.7	97.2		113.9	109.8	L_W Database
	Conveyor belt	L_W"	67.0	61.0	65.0	66.0	64.0	52.0	40.0		72.1	67.1	L_W Database
DMS 2 and 3 circuits	New DMS 3 prep screen	L_W	113.3	109.0	108.4	108.4	108.2	105.8	102.4		117.4	112.6	L_W Database
	New drain and rinse screen	L_W	111.4	102.7	100.5	102.0	95.6	90.8	86.1		112.8	101.9	L_W Database
Roll crushers and ancillary circuits	New middlings re-crusher facility	L_W	113.0	113.0	115.0	119.0	111.0	106.0	98.0		122.3	117.9	L_W Database
Spiral Plant	Sump pump	L_W	81.5	82.5	84.5	84.5	87.5	84.5	80.5	74.5	92.7	91.1	L_W Predictions (Bruce & Moritz, 1998)
Water Services	Water supply pump	L_W	82.8	83.8	85.8	85.8	88.8	85.8	81.8	75.8	94.0	92.3	L_W Predictions (Bruce & Moritz, 1998)

Table 6: The directivity of the primary and secondary scrubber stack source

Description	Value	Unit
Stack height	5.5	m
Exit diameter	0.45	m
Exit velocity	16	m/s
Exit temperature	25	°C

The reader is reminded of the non-linearity in the addition of L_W's. If the difference between the sound power levels of two sources is nil the combined sound power level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound power levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Therefore, although some sources of noise could not be quantified (e.g. light vehicle movements, etc.), the incremental contributions of such sources are expected to be minimal given that the majority of sources are considered in the source inventory.

4.3 Noise Propagation and Simulated Noise Levels

The propagation of noise generated during the operational phase was calculated with CadnaA in accordance with ISO 9613. Meteorological and site-specific acoustic parameters as discussed in Section 3.2 along with source data discussed in 4.2, were applied in the model.

Table 7 provides a summary of simulated noise levels for the project operations at closest NSRs within the study area. Simulated noise levels due to project operations are also presented in isopleth form (Figure 15 and Figure 16).

Noise levels due to project operations are not predicted to exceed the IFC noise guidelines for residential areas at any potential NSR within the study area.

For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. The largest change to baseline noise levels, due to project operations, was predicted at the Uis Mining Village ~1.7 km east of the plant for day-time conditions (2.3 dBA). According to SANS 10103 (2008); this increase in noise levels is expected to be imperceptible.

Table 7: Summary of simulated noise levels (provided as dBA) for proposed project operations at NSRs within the study area

Noise Sensitive Receptor	Project operations [(a)]		Baseline		Increase Above Baseline [(c)]	
	Day	Night	Day	Night	Day	Night
Uis	18.2	19.2	39.2	44.1	0.0	0.0
Uis Mining Village ~1.7 km east of the plant	35.6	34.8	37.1	55.2	2.3	0.0
Tatamutsi	0	0	46.1	33.2	0.0	0.0
Individual homesteads at and to the east of sampling site 5 (NSR12, NSR13, NSR14, NSR15 – Figure 1)	0	0	32.9	47.5	0.0	0.0
Individual homesteads at sampling site 6 (NSR16 – Figure 1)	0	0	38.9	26.5	0.0	0.0
Individual homesteads ~1.6 km northwest of sampling site 5 (NSR0, NSR1, NSR2, NSR3, NSR4, NSR5, NSR6, NSR7 – Figure 1) (baseline measurements at site 5 assumed representative of the site)	0	0	32.9 [(b)]	47.5 [(b)]	0.0	0.0

Notes:

(a) Exceedance of day- and night-time IFC guideline for residential areas is provided in bold

(b) Baseline measurements based on closest sampling sites.

(c) Likely community response in accordance with the SANS 10103:

< 3 dBA	*< 5 dBA*	*< 10 dBA*	*< 15 dBA*	*< 20 dBA*
Change imperceptible	*No reaction*	*'Little' reaction with sporadic complaints*	*'Medium' reaction with widespread complaints*	*'Strong' to 'very strong' reaction with threats of community action or vigorous community action.*

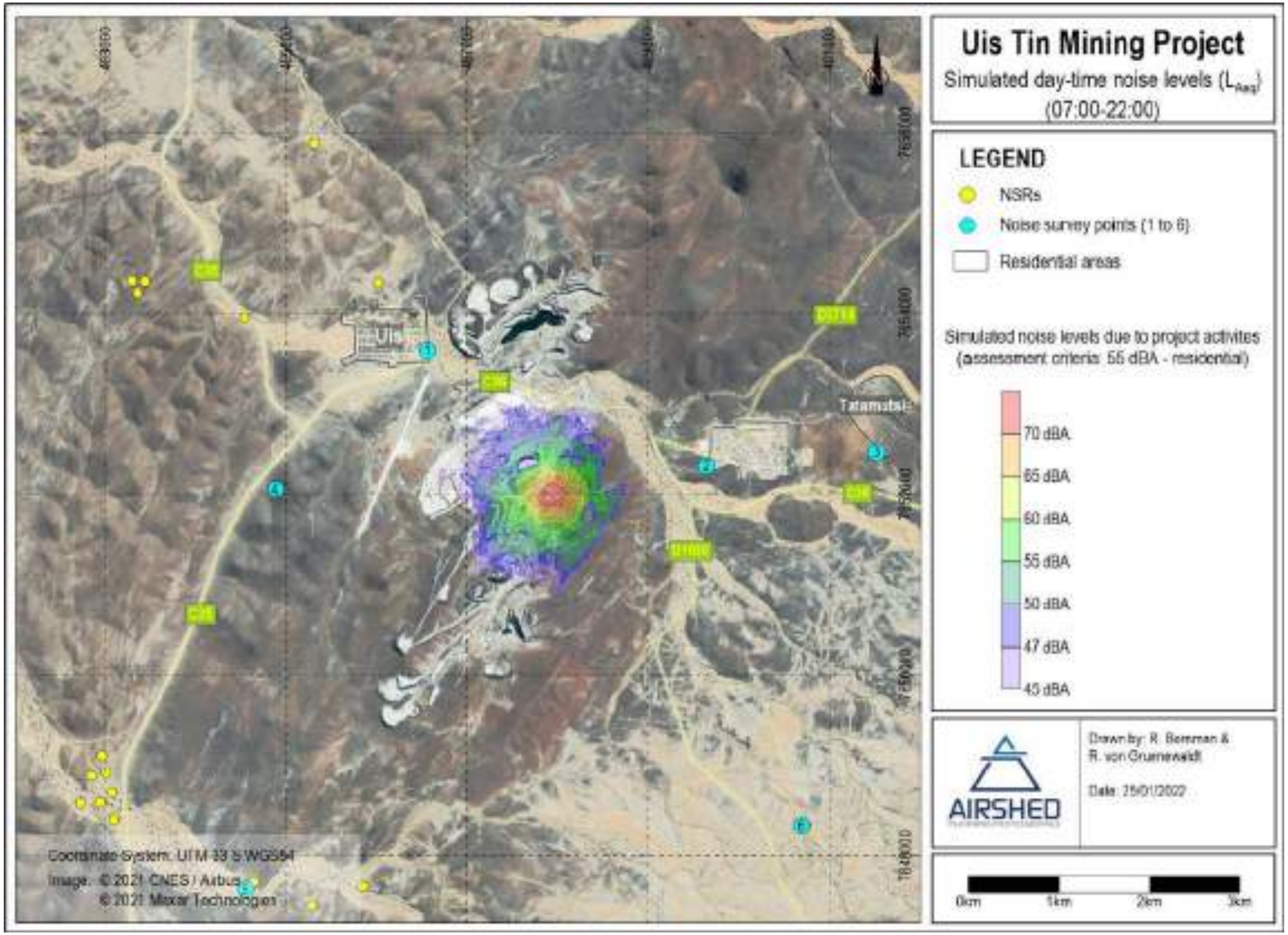


Figure 15: Simulated day-time noise levels due to proposed project operations

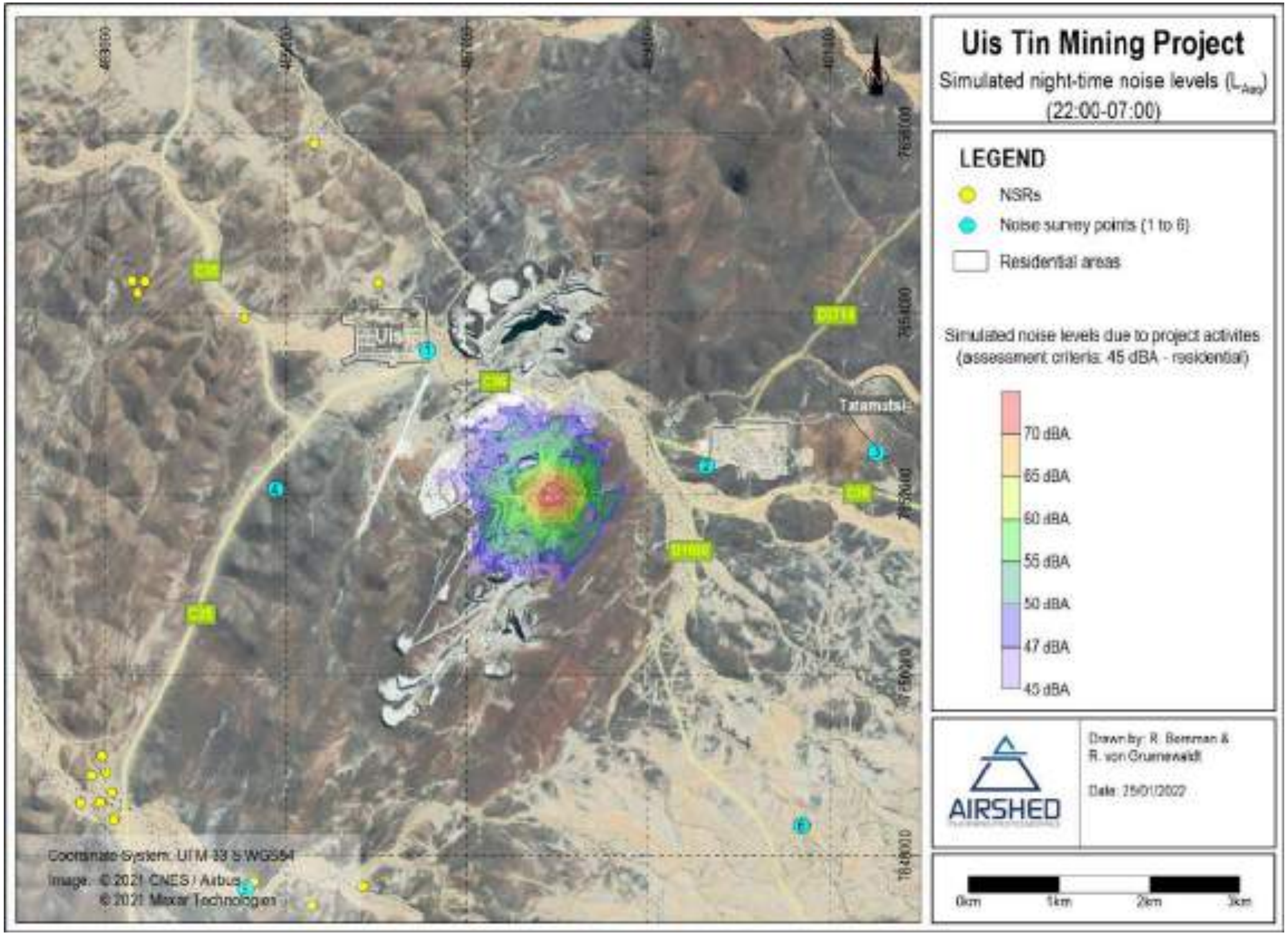


Figure 16: Simulated night-time noise levels due to proposed project operations

5 Impact Significance Rating

The significance of environmental noise impacts was assessed according to the methodology adopted by ECC.

Due to the proximity of potential NSRs to the project activities, the significance of construction, operation and decommissioning phase noise impacts is ***minor.*** The impact assessment has been provided in a separate impact assessment spreadsheet to ECC.

6 Management Measures

In the quantification of noise emissions and simulation of noise levels as a result of the project, it was found that environmental noise evaluation criteria for residential, educational, and institutional receptors will be met at all off-site noise sensitive receptors.

The measures discussed in this section are measures typically applicable to industrial sites and are considered good practice by the IFC (2007) and British Standard BSI (2008).

It should be noted that not all mitigation measures are to be implemented, but should the need arise the mitigation measures as discussed in this section can be considered.

6.1 Controlling Noise at the Source

6.1.1 General Good Practice Measures

Good engineering and operational practices will reduce levels of annoyance. For general activities, the following good engineering practice should be applied to all project phases:

- Unless it is an emergency situation, non-routine noisy activities such as construction, decommissioning, start-up and maintenance, should be limited to day-time hours.
- A complaints register, including the procedure which governs how complaints are received, managed and responses given, must be implemented, and maintained.

6.1.2 Specifications and Equipment Design

Equipment to be employed should be reviewed to ensure the quietest available technology is used. Equipment with lower sound power levels must be selected in such instances and vendors/contractors should be required to guarantee optimised equipment design noise levels.

6.1.3 Enclosures

As far as is practically possible, sources of significant noise should be enclosed. The extent of enclosure will depend on the nature of the machine and their ventilation requirements. Pumps are examples of such equipment.

It should be noted that the effectiveness of partial enclosures and screens can be reduced if used incorrectly, e.g. noise should be directed into a partial enclosure and not out of it, there should not be any reflecting surfaces such as parked vehicles opposite the open end of a noise enclosure.

6.1.4 Use and Siting of Equipment and Noise Sources

The following good practice should be implemented:

- Machines and mobile equipment used intermittently should be shut down between work periods or throttled down to a minimum and not left running unnecessarily. This will reduce noise and conserve energy.
- Acoustic covers of engines should be kept closed when in use or idling.
- Reduction of operational frequency of low-pressure compressors can be considered during night-time conditions to further reduce noise impacts.

6.1.5 Maintenance

Regular and effective maintenance of equipment are essential to noise control. Increases in equipment noise are often indicative of eminent mechanical failure. Also, sound reducing equipment/materials can lose effectiveness before failure and can be identified by visual inspection.

6.2 Monitoring

In the event that noise related complaints are received short term ambient noise measurements, at the complainant, should be conducted as part of investigating the complaints. The results of the measurements should be used to inform any follow up interventions. The investigation of complaints should include an investigation into equipment or machinery that likely result or resulted in noise levels annoying to the community. This could be achieved with source noise measurements.

The following procedure should be adopted for all noise surveys (for complaints):

- Any surveys should be designed and conducted by a trained specialist.
- Sampling should be carried out using a Type 1 SLM that meets all appropriate IEC standards and is subject to annual calibration by an accredited laboratory.
- The acoustic sensitivity of the SLM should be tested with a portable acoustic calibrator before and after each sampling session.
- Samples sufficient for statistical analysis should be taken with the use of portable SLM's capable of logging data continuously over the time period. Samples, representative of the day- and night-time acoustic environment should be taken.
- The following acoustic indices should be recoded and reported: $L_{Aeq\ (T)}$, statistical noise level L_{A90}, L_{AFmin} and L_{AFmax}, octave band or 3rd octave band frequency spectra.
- The SLM should be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- Efforts should be made to ensure that measurements are not affected by the residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer. It is good practice to avoid conducting measurements when the wind speed is more than 5 m/s, while it is raining or when the ground is wet.
- A detailed log and record should be kept. Records should include site details, weather conditions during sampling and observations made regarding the acoustic environment of each site.

7 Conclusion

Based on the findings of the assessment and provided the recommended general "good practice" management and mitigation measures are in place, it is the specialist opinion that the project may be authorised.

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SANS 10103, 2008. *The measurement and rating of environmental noise with respect to annoyance and to speech communication,* Pretoria: Standards South Africa.

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Appendix A – Specialist Curriculum Vitae

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Reneé von Gruenewaldt (nee Thomas)
Profession	Air Quality and Environmental Noise Scientist
Date of Birth	13 May 1978
Years with Firm	19 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

Reneé von Gruenewaldt (Air Quality Scientist): Reneé joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over nineteen (19) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and eight (8) years of experience in the field of environmental noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various air quality modelling packages including the AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff-based model (CALPUFF and CALMET), puff-based HAWK model and line-based models. Her experience with air emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of wastewater treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise and CadnaA for propagation of industrial, road and rail noise sources.

Having worked on projects throughout Africa (i.e., South Africa, Mozambique, Malawi, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar and Egypt for Air Quality Impact Assessments and Mozambique, Namibia, Botswana, Kenya, Ghana, Suriname and Afghanistan for Environmental Noise Impact Assessments) Reneé has developed a broad experience base. She has a good understanding of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

RELEVANT EXPERIENCE (AIR QUALITY)

Mining and Ore Handling

Reneé has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite, manganese and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for numerous mines over Mpumalanga (viz. Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein, Hartogshoop, Belfast, New Largo, Geluk, etc.), Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Flourspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi), Kusile Rail (SA) and WCL Rail (Liberia).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC), and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infrachem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol (at Elrode) and Island View (in Durban) tanks quantification, Petro SA and Chevron (including the postponement/exemption application).

Pulp and Paper Industry

Air quality studies have been undertaken or the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the ash expansion projects at Kusile, Kendal, Hendrina, Kriel and Arnot, Fabric Filter Plants at Komati, Grootvlei, Tutuka, Lethabo and Kriel Power Stations; the proposed Kusile, Medupi (including the impact assessment for the Flue Gas Desulphurization) and Vaal South Power Stations. Reneé was also involved and the cumulative assessment of the existing and return to service Eskom power stations assessment and the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of Pebble Bed Modular Reactor and nuclear plants at Duynefontein, Bantamsklip and Thyspunt.

Apart from Eskom projects, power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Paratus Power Plant).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill, Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill), Cape Winelands District Municipality Landfill and the Tsoeneng Landfill (Lesotho). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town), the Ergo Rubber Incinerator and the Ecorevert Pyrolysis Plant.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

Reneé undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modeling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

Reneé has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

RELEVANT EXPERIENCE (NOISE)

Mining

Reneé has undertaken numerous environmental noise assessments for mining operations. These include environmental noise impact assessments including baseline noise surveys for Balama (Mozambique), Masama Coal (Botswana), Lodestone (Namibia), Prieska (SA), Kolomela (SA) Heuningkranz (SA), Syferfontein (SA), South 32 (SA), Mamatwan and Marula Platinum Mine (SA).

Power Generation

Environmental noise assessments have been completed for numerous Eskom coal fired power station studies in SA including the Kriel Fabric Filter Plant, Kendal ash facility, Medupi ash facility. Apart from Eskom projects, power plant assessments have also been completed in Botswana (Morupule), Kenya (Or Power geothermal power plants), Suriname (EBS power plant) and SA (Richards Bay combined cycle power plant).

Process Operations

Environmental noise assessments have been undertaken for various process operations including waste disposal facilities (Bon Accord in Gauteng), bottling and drink facilities (Imali and Isanti Project in Gauteng) and Smelter (Gamsberg in Northern Cape).

Transport

An environmental noise assessment was completed for the Obetsebi road expansion and flyover project in Ghana.

Gas Pipelines

An environmental noise assessment is currently being undertaken for the Sheberghan gas pipeline in Afghanistan.

Baseline Noise Surveys

Baseline noise surveys have been undertaken for numerous mining and process operation activities (including Raumix quarries and Sibanye Stillwater Platinum Mines (SA)) in support of onsite Environmental Management Programmes.

OTHER EXPERIENCE (2001)

Research for B.Sc Honours degree was part of the "Highveld Boundary Layer Wind" research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: *An Air Quality Baseline Assessment for the Vaal Airshed in South Africa*
B.Sc Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)
ARCINFO	GIMS, Course: Introduction to ARCINFO 7 (2001)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Botswana, Ghana, Suriname, Afghanistan, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Lesotho, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Understanding the Synoptic Systems that lead to Strong Easterly Wind Conditions and High Particulate Matter Concentrations on The West Coast of Namibia, H Liebenberg-Enslin, R von Gruenewaldt, H Rautenbach and L Burger. National Association for Clean Air (NACA) conference, October 2017.
- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High-Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas. Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Fair	Fair

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and my experience.

Signature of staff member

24/05/2021

Date (Day / Month / Year)

Full name of staff member: Reneé Georgeinna von Gruenewaldt

Curriculum Vitae: René von Gruenewaldt 7

Appendix B – Declaration of Independence

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: René von Gruenewaldt
Name of Registration Body: South African Council for Natural Scientific Professions
Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:
I, René von Gruenewaldt, declare that:

- I act as the independent specialist;
- I am conducting any work and activity relating to the proposed FCR plant and PGM flotation plant Project in an objective manner, even if this results in views and findings that are not favourable to the client;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have the required expertise in conducting the specialist report and I will comply with legislation and any guidelines that have relevance to the proposed activity;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority.
- All the particulars furnished by me in this declaration are true and correct.

Signed at Pretoria on this 27th of January 2022

SIGNATURE
Principal Noise Scientist
CAPACITY OF SIGNATORY

Appendix C – Sound Level Meter Calibration Certificates

sanas
Calibration Laboratory
148
1302

M AND N ACOUSTIC SERVICES (Pty) Ltd
Co. Reg. No. [illegible] VAT NO. [illegible] BEE Status: Level 4
P.O. Box 57713, Pierre van Ryneveld, 0045
No. 15, Mu[illegible] Avenue
Pierre van Ryneveld, 0045
Tel: 012 689-2007 | 076 [illegible] • Fax: [illegible] 4690
E-mail: admin@mnacoustics.co.za
Website: www.mnacoustics.co.za

CERTIFICATE OF CONFORMANCE

CERTIFICATE NUMBER	2021-AS-0246
ORGANISATION	AIRSHED PLANNING PROFESSIONALS (PTY) LTD
ORGANISATION ADDRESS	P.O. BOX 5260, HALFWAY HOUSE, 1685
CALIBRATION OF	ACOUSTIC CALIBRATOR
MANUFACTURER	SVANTEK
MODEL NUMBER	SV 33
SERIAL NUMBER	43170
DATE OF CALIBRATION	02 MARCH 2021
RECOMMENDED DUE DATE	-------------------
PAGE NUMBER	PAGE 1 OF 3

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The measurement results recorded in this certificate were correct at the time of calibration. The subsequent accuracy will depend on factors such as care, handling, frequency of use and the amount of different users. It is recommended that re-calibration should be performed at an interval, which will ensure that the instrument remains within the desired limits and/or manufacturer's specifications.

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Calibrated by:	Authorised/Checked by:	Date of Issue:
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDE (SANAS TECHNICAL SIGNATORY)	02 MARCH 2021

Director: Marianka Naudé

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1. Services are carried out at the discretion of M and N Acoustic Services, which reserves the right to decline any application for performance or services when deemed to be outside the scope of services of this Company.
2. Through acceptance of the original quotation, the Applicant agrees to the quoted fee and the conditions state herein. In cases where M and N Acoustic Services has not published the amount of the fee, M and N Acoustic Services will in good faith give estimates of the time and cost of the service based upon its previous experience.
3. Payment is strictly COD, or 30 days from the date of invoice, or as mutually agreed in writing between the Applicant and M and N Acoustic Services before the service is commenced. M and N Acoustic Services retains the right to ask for a deposit for services.
4. All instruments, items of equipment, etc. sent by the Applicant for performance of service shall be delivered and collected at the Applicant's own cost and risk.
5. M and N Acoustic Services cannot guarantee to complete the work within the estimated time and cost but will consult the Applicant of it becomes apparent that either estimate will be exceeded.
6. If a service is not completed because of defects or deficiencies in the item submitted by the applicant, an appropriate reduction in the fee may be allowed depending on the amount of work already performed. The normal practice will be to charge the fee in full.
7. The Applicant hereby consents that the legal liability of M and N Acoustic Services with regard to any damage whatsoever or a mistake made by M and N Acoustic Services in services performed for the Applicant will be limited to the original quoted fee.
8. Regarding certificates and reports:
    - A certificate or report will be furnished to the Applicant on completion of the service.
    - Additional certified copies of certificates, or re-issued certificates will be subjected to an additional fee, as determined on a case by case basis.
    - The values in the issued certificates are correct at the time of calibration. Subsequently the accuracy will depend on such factors as the care exercised in handling and use of the instrument and the frequency of use.
    - Re-calibration should be performed after a period which has been chosen to ensure that the instrument's accuracy remains within the desired limits.

1. **PROCEDURE**

The UUT was calibrated according to the procedures 1002/P/001 and also to the IEC 60942 specifications for Sound Level Calibrators as well as the manufacturer's specifications.

2. **MEASURING EQUIPMENT**

Keysight	34461A	Digital Multimeter	MY 53223905
Greysinger	80 CL	Environmental Logger	02304030/1/2
G.R.A.S	42 AP	Piston Phone	256092
G.R.A.S	26 AJ	½" Pre-Amplifier	188476
B&K	2363	Measuring Amplifier	1232647
G.R.A.S	40 AG	½" Microphone	19721
Leader	LDM-170	Distortion Meter	0100240
Svantek	SV 35	Acoustic Calibrator	58106
LG	FC-7015	Universal Counter	00022701
Agilent	34461A	Digital Multimeter	MY 53205694
G.R.A.S	42 AG	Multi-Frequency Calibrator	279025

3. **RESULTS**

3.1 The following parameters of the Calibrator were calibrated:

Output Level	IEC 60942: Section 5.2.3
Output Frequency	IEC 60942: Section 5.3.3
Selective Distortion	IEC 60942: Section A.4.9

The Calibrator output level was found to be 114,1 dB at 1 000 Hz.
No adjustment was made.

These results were corrected to the ambient condition of 1 013,25 Pa.

Conclusion: The Calibrator complied with the above-specified clauses of the IEC 60942 specification and requirements according to ARP 0109:2014. **Class 1.**

Calibrated by:	Approved/Checked by:
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDE (SANAS TECHNICAL SIGNATORY)

Director: Marianka Naudé

4. REMARKS

4.1 The reported expanded uncertainties of measurements are based on a standard uncertainty multiplied by a coverage factor of $k=2$, providing a level of confidence of approximately 95,45 %, the uncertainties of measurements have been estimated in accordance with the principles defined in the GUM (Guide to Uncertainty of Measurement) ISO, Geneva, 1993.

4.2 The environmental conditions were: Temperature: (23 ± 2) °C
Relative Humidity: (50 ± 15) %RH

4.3 Calibration labels bearing cal date, due date (if requested), certificate number and serial number have been affixed to the instrument.

4.4 The above statement of conformance is based on the measurement values obtained, extended by the estimated uncertainty of measurement, being within the appropriate specification limits

4.5 The uncertainty of measurements was estimated as follows:

Acoustic Calibrator: ± 0,19 dB

4.6 The results on this Certificate relates only to the items and parameters calibrated.

------------SECTION 4.5 THE END OF CERTIFICATE-----------

Calibrated by:	Authorised/Checked by:
W.N SIBANYONI *(CALIBRATION TECHNICIAN)*	*M. NAUDE* *(SANAS TECHNICAL SIGNATORY)*

Director: Marianka Naudé

sanas
Calibration Laboratory
148
1302

M AND N ACOUSTIC SERVICES (Pty) Ltd
Co. Reg. No. [illegible] VAT NO. 4900295876 BEE Status: Level 4
P.O. Box [illegible], [illegible] Rynevald, 0045
No. 15, [illegible] Avenue
Pierre van Ryneveld, [illegible]
Tel: 012 689-2007 | 076 [illegible] • Fax: [illegible] 211 4690
E-mail: [illegible]
Website: www.mnacoustics.co.za

CERTIFICATE OF CALIBRATION

CERTIFICATE NUMBER	2021-AS-0250
ORGANISATION	AIRSHED PLANNING PROFESSIONALS (PTY) LTD
ORGANISATION ADRESS	P.O. BOX 5260, HALFWAY HOUSE, 1685
CALIBRATION OF	SOUND & VIBRATION ANALYZER complete with built-in ⅓-OCTAVE/OCTAVE FILTER, ½" PRE-AMPLIFIER and ½" MICROPHONE
MANUFACTURERS	SVANTEK and ACO
MODEL NUMBERS	SVAN 977, SV 12L and 7052E
SERIAL NUMBERS	36183, 40659 and 78692
DATE OF CALIBRATION	01-02 MARCH 2021
RECOMMENDED DUE DATE	------------------------
PAGE NUMBER	PAGE 1 OF 6

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The measurement results recorded in this certificate were correct at the time of calibration. The subsequent accuracy will depend on factors such as care, handling, frequency of use and the number of different users. It is recommended that re-calibration should be performed at an interval, which will ensure that the instrument remains within the desired limits and/or manufacturer's specifications.

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Calibrated by:	Authorised/Checked by:	Date of Issue:
W.A. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDE (SANAS TECHNICAL SIGNATORY)	03 MARCH 2021

Director: Marianka Naudé

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2. Through acceptance of the original quotation, the Applicant agrees to the quoted fee and the conditions state herein. In cases where M and N Acoustic Services has not published the amount of the fee, M and N Acoustic Services will in good faith give estimates of the time and cost of the service based upon its previous experience.
3. Payment is strictly COD, or 30 days from the date of invoice, or as mutually agreed in writing between the Applicant and M and N Acoustic Services before the service is commenced. M and N Acoustic Services retains the right to ask for a deposit for services.
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   - The values in the issued certificates are correct at the time of calibration. Subsequently the accuracy will depend on such factors as the care exercised in handling and use of the instrument and the frequency of use.
   - Re-calibration should be performed after a period which has been chosen to ensure that the instrument's accuracy remains within the desired limits.

1. PROCEDURE

The Integrating Sound Level Meter was calibrated according to procedure 1002/P/013 and to the IEC 61672-3:2006 specifications as well as the manufacturer's specifications.

The ½" Microphone was calibrated according to procedure 1002/P/002 and 1002/P/011 as well as the manufacturer's specifications.

The ⅓-Octave/Octave Filter was calibrated according to procedure 1002/P/008 and to the IEC 61260 specification as well as the manufacturer's specifications.

2. MEASURING EQUIPMENT

JFW	50BR-022	50 Ohm Step Attenuator	4610290708
Agilent	33522A	Function Generator	MY 50005443
Agilent	34461A	Digital Multimeter	MY 53224004
Onset	UX100-011	Environmental Logger	2047747
Majortech	MT669	Environmental Logger	150828469
Svantek	SV 35	Acoustical Calibrator	58106
Keysight	34461A	Digital Multimeter	MY 53223905
G.R.A.S	42 AP	Piston Phone	256092
G.R.A.S	26 AJ	½" Pre-Amplifier	188476
G.R.A.S	40 AG	½" Microphone	19721
B&K	4226	Multi-Functional Calibrator	3081642
Greysinger	80 CL	Data Logger	02304030/1/2
Gems	3500B0001A01B000	Pressure Sensor	1606-0204475
B&K	2829	4-Ch Microphone Power Supply	2329283

Calibrations performed by this laboratory are in terms of standards, the accuracies of which are traceable to national measuring standards as maintained by NMISA.

Calibrated by:	Authorized/Checked by:
W.X. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDE (SANAS TECHNICAL SIGNATORY)

Director: Marianka Naude

3. RESULTS - ACCORDING TO THE IEC 61672-3: 2006:

3.1 The following parameters of the Integrating Sound Level Meter were calibrated:

Parameter	Specification	Uncertainty of Measurement in dB
Calibration Check Frequency at 114,0 dB at 1 000 Hz at Nominal Range: High	IEC 61672-3: Clause 9	± 0,3
Self-Generated Noise: A-Weighted with Microphone 37,7 dB A-Weighted Electrical 1,1 dB C-Weighted Electrical 0,0 dB Z-Weighted Electrical 3,7 dB B-Weighted Electrical - 0,2 dB	IEC 61672-3: Clause 10	-------
Level Linearity at 8 000 Hz Nominal Range: High Reference Level at 114,0 dB: (59,3 dB to 148,9 dB)	IEC 61672-3: Clause: 14	± 0,3
Level Range Control at 1 000 Hz Reference Level at 114,0 dB Nominal Range: High Low Range	IEC 61672-3: Clause: 15	± 0,3
Frequency and Time Weightings at 1 000 Hz at 114,0 dB	IEC 61672-3: Clause 13	± 0,3
Tone Burst Response (Max. Fast, Max. Slow, LA_{eq} and SEL)	IEC 61672-3: Clause 16	± 0,3

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Director: Marianka Naudé

Parameter	**Specification**	**Uncertainty of Measurement in dB**
A-Weighting Network (31,5 to 20 000) Hz	IEC 61672-3: Clause 12	± 0,3
C-Weighting Network (31,5 to 20 000) Hz	IEC 61672-3: Clause 12	± 0,3
Z- Weighting Network (31,5 to 20 000) Hz	IEC 61672-3: Clause 12	± 0,3
B- Weighting Network (31,5 to 20 000) Hz	IEC 61672-3: Clause 12	± 0,3
Peak, C Low Peak Range	IEC 61672-3: Clause 17	± 0,3

Conclusion: The Integrating Sound Level Meter complied with the above-specified clauses of the IEC 61672-3:2006 specifications and requirements according to ARP 0109:2014. **Class 1.**

3.2 The following parameters of the built-in ⅓-Octave/Octave Filter were calibrated:

Octave Frequency Response (31,5 to 16 000) Hz	IEC 61260: Sections 4.7 & 5.6
⅓-Octave Frequency response (25 to 20 000) Hz	IEC 61260: Sections 4.7 & 5.6

The uncertainty of measurement was estimated as follows: ± 0,3 dB

Conclusion: The built-in Octave Filter complied with the above-specified clauses of the IEC 61260 specification. **Class 1.**

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W.S. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDE (SANAS TECHNICAL SIGNATORY)

Director: Marienka Naude

3.3 The following parameters of the ½" Microphone were calibrated and the results were corrected to the ambient condition of 1 013,25 mBar:

Output Sensitivity at 250 Hz at 94,0 dB
Frequency Response (31,5 to 16 000) Hz

The uncertainty of measurements was estimated as follows: ± 0,3 dB

Conclusion: The parameters measured for the ½" Microphone, complied with the manufacturer's specification.

3.4 The ½" Microphone was calibrated Electroacoustic according to Clause 12 of IEC 61672-3: 2006 complete with Integrating Sound Level Meter and Svantek SV 12L ½" Pre-amplifier Serial No: 25686, free-field corrections were taken into consideration and the results were corrected to the ambient condition of 1 013,25 mBar:

FREQUENCY (Hz)	CALCULATED EXPECTED VALUE (dB)	MEASURED VALUE (dB)	DEVIATION (dB)	UoM (dB)
1 000 (Ref)	114,1	114,1	0,0	± 0,3
31,5	111,3	111,2	- 0,1	± 0,3
63	113,4	113,3	- 0,1	± 0,3
125	113,9	113,9	0,0	± 0,3
250	114,1	114,0	- 0,1	± 0,3
500	114,0	114,0	0,0	± 0,3
1 000	114,1	114,1	0,0	± 0,3
2 000	113,9	113,9	0,0	± 0,3
4 000	113,4	113,5	+ 0,1	± 0,3
8 000	109,4	109,2	- 0,2	± 0,3
12 500	106,5	106,9	+ 0,4	± 0,3
16 000	103,3	104,0	+ 0,7	± 0,3

Calibrated by:	Authorized/Checked by:
W.S.SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDE (SANAS TECHNICAL SIGNATORY)

Director: Marianka Naudé

4. REMARKS

4.1 The reported expanded uncertainties of measurements are based on a standard uncertainty multiplied by a coverage factor of $k=2$, providing a level of confidence of approximately 95.45 %, the uncertainties of measurements have been estimated in accordance with the principles defined in the GUM (Guide to Uncertainty of Measurement) ISO, Geneva, 1993

4.2 The environmental conditions during calibration of items in section 3 were:
Temperature: (23 ± 2) °C
Relative Humidity: (50 ± 15) %RH

4.3 Calibration labels bearing cal date, due date (if requested), certificate number and serial number have been affixed to the instrument.

4.4 The above statement of conformance is based on the measurement values obtained, extended by the estimated uncertainty of measurement, being within the appropriate specification limits

4.5 The microphone's frequency range determines the useful frequency range of the sound level meter and vice versa.

4.6 The results on this Certificate relates only to the items and parameters calibrated.

4.7 Abbreviation:
UoM = Uncertainty of Measurement

------------SECTION 4.7 THE END OF CERTIFICATE-----------

Calibrated by:	Authorised/Checked by:
W.S. SIBANYONI (CALIBRATION TECHNICIAN)	M. NAUDÉ (SANAS TECHNICAL SIGNATORY)

Director: Marianka Naudé

Appendix D – Time-series, Statistical, and Frequency Spectrum Results

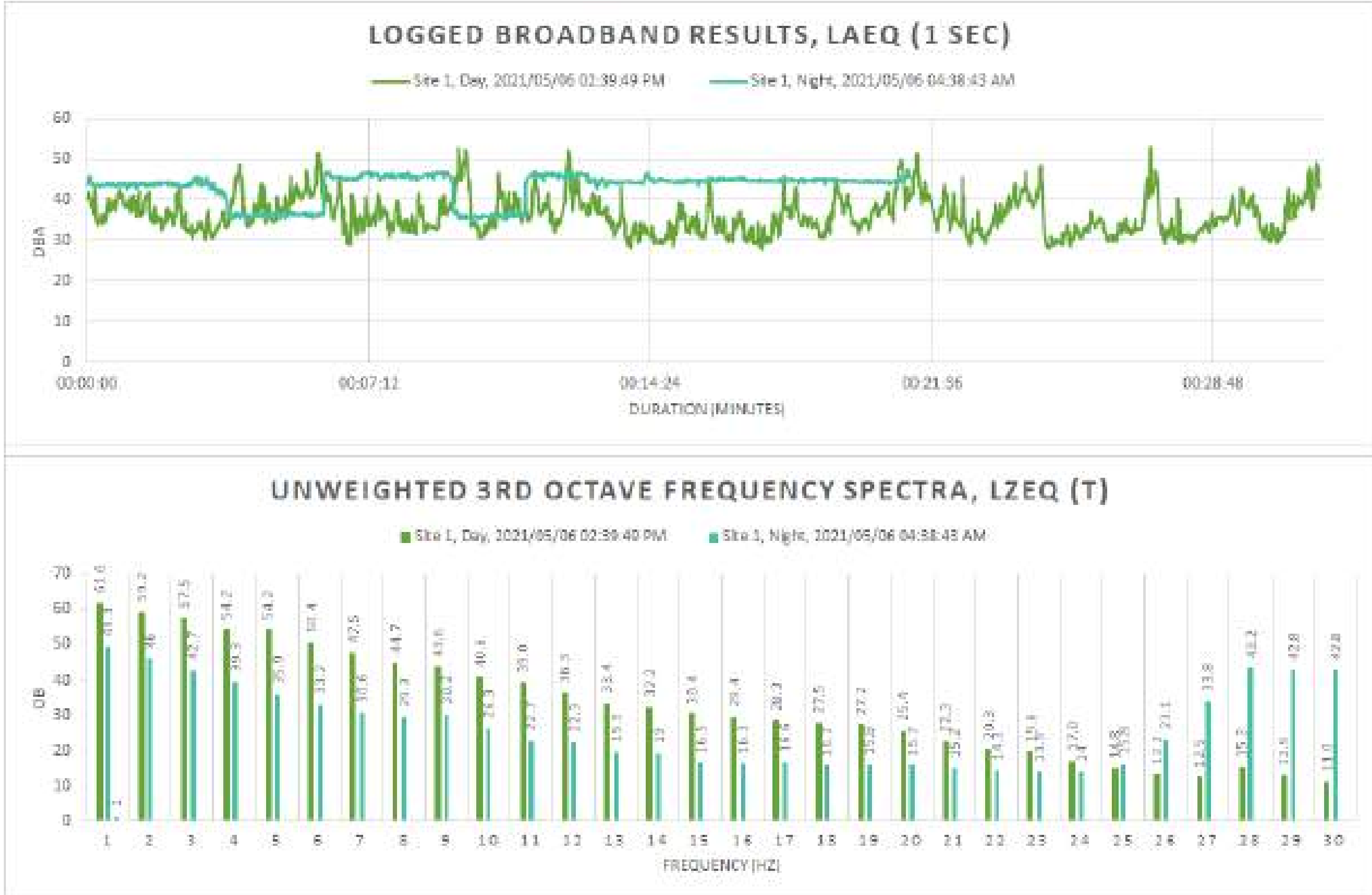


Figure 17: Detailed survey results for Site 1

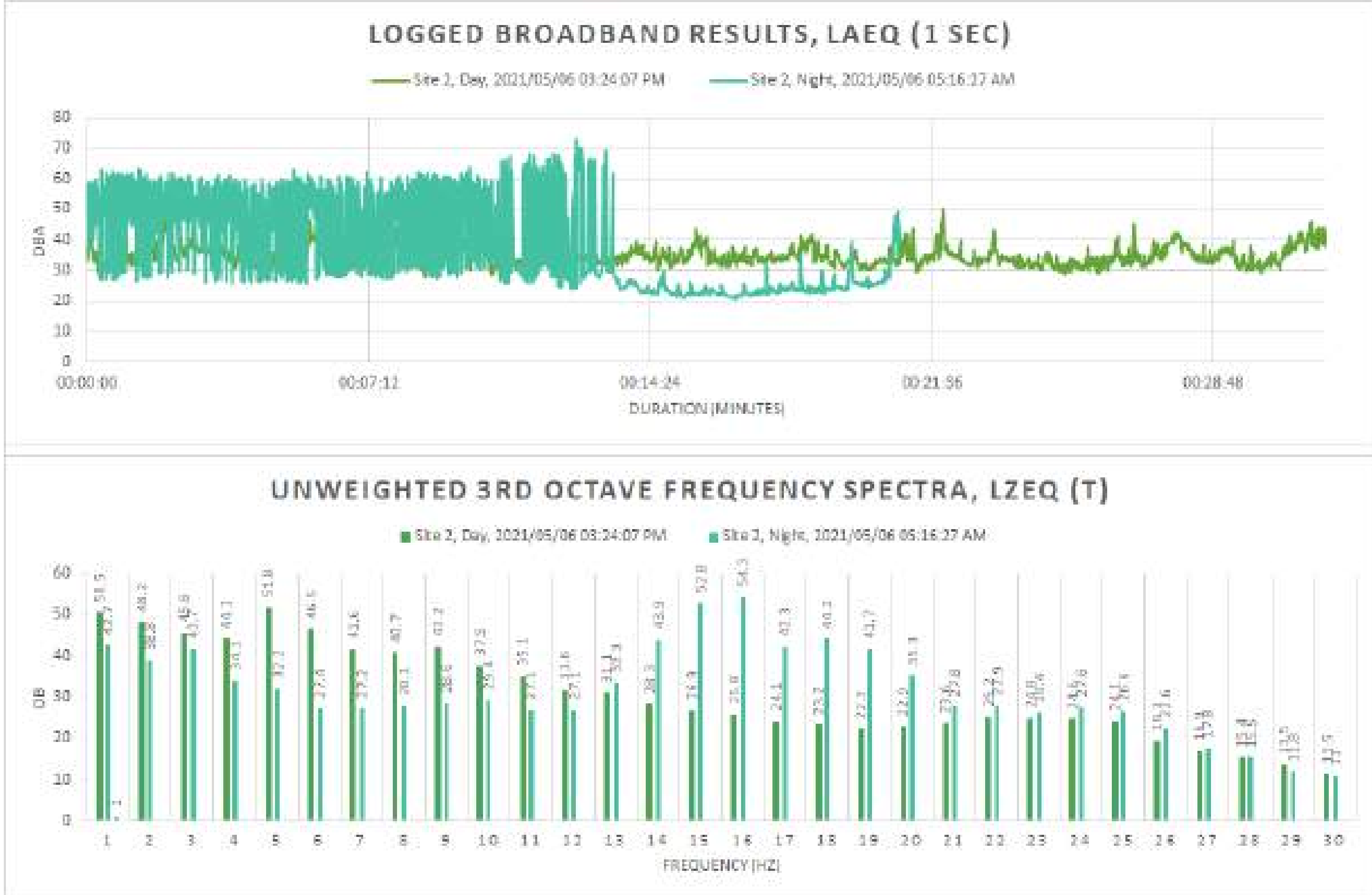


Figure 18: Detailed survey results for Site 2

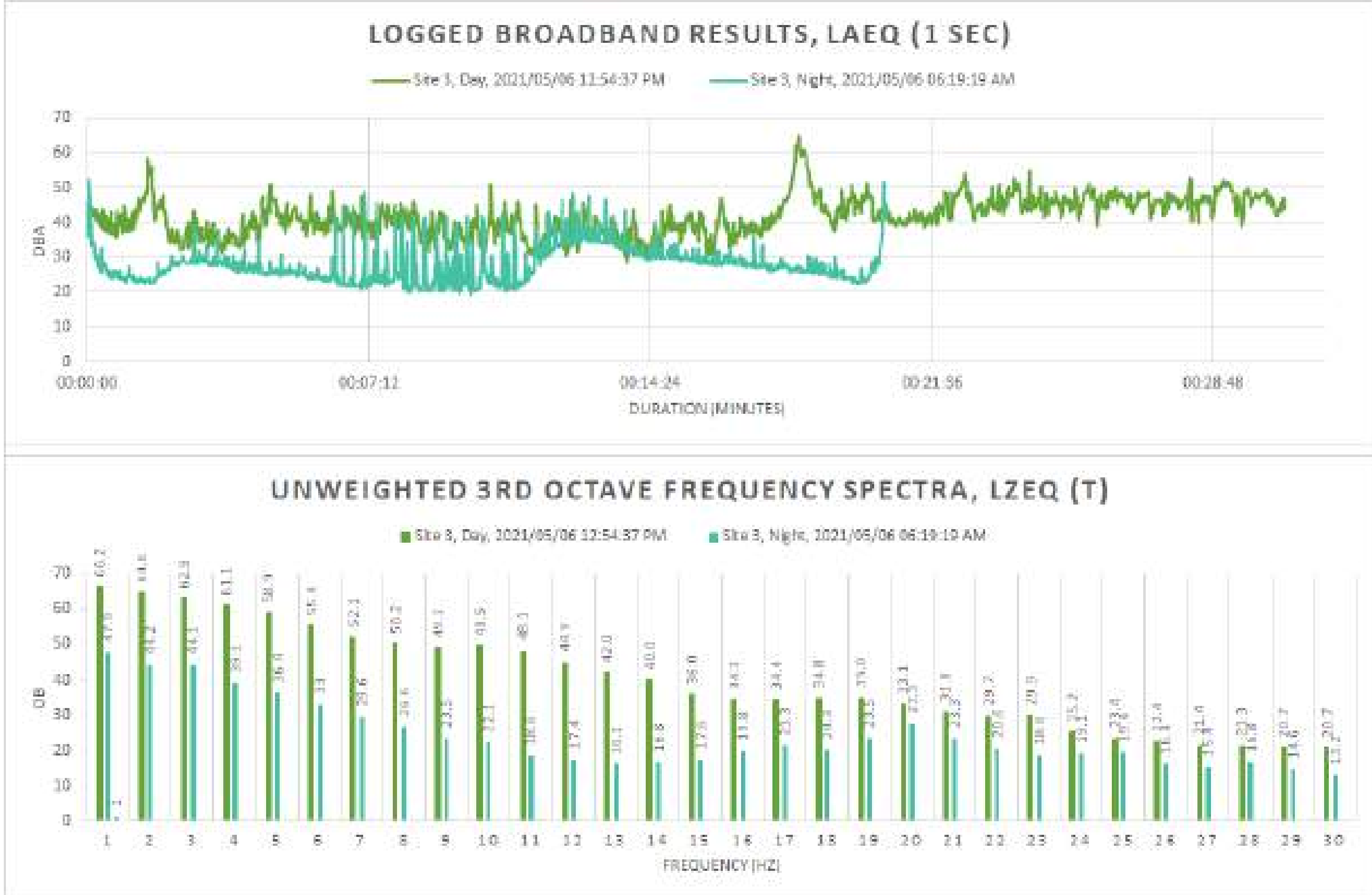


Figure 19: Detailed survey results for Site 3

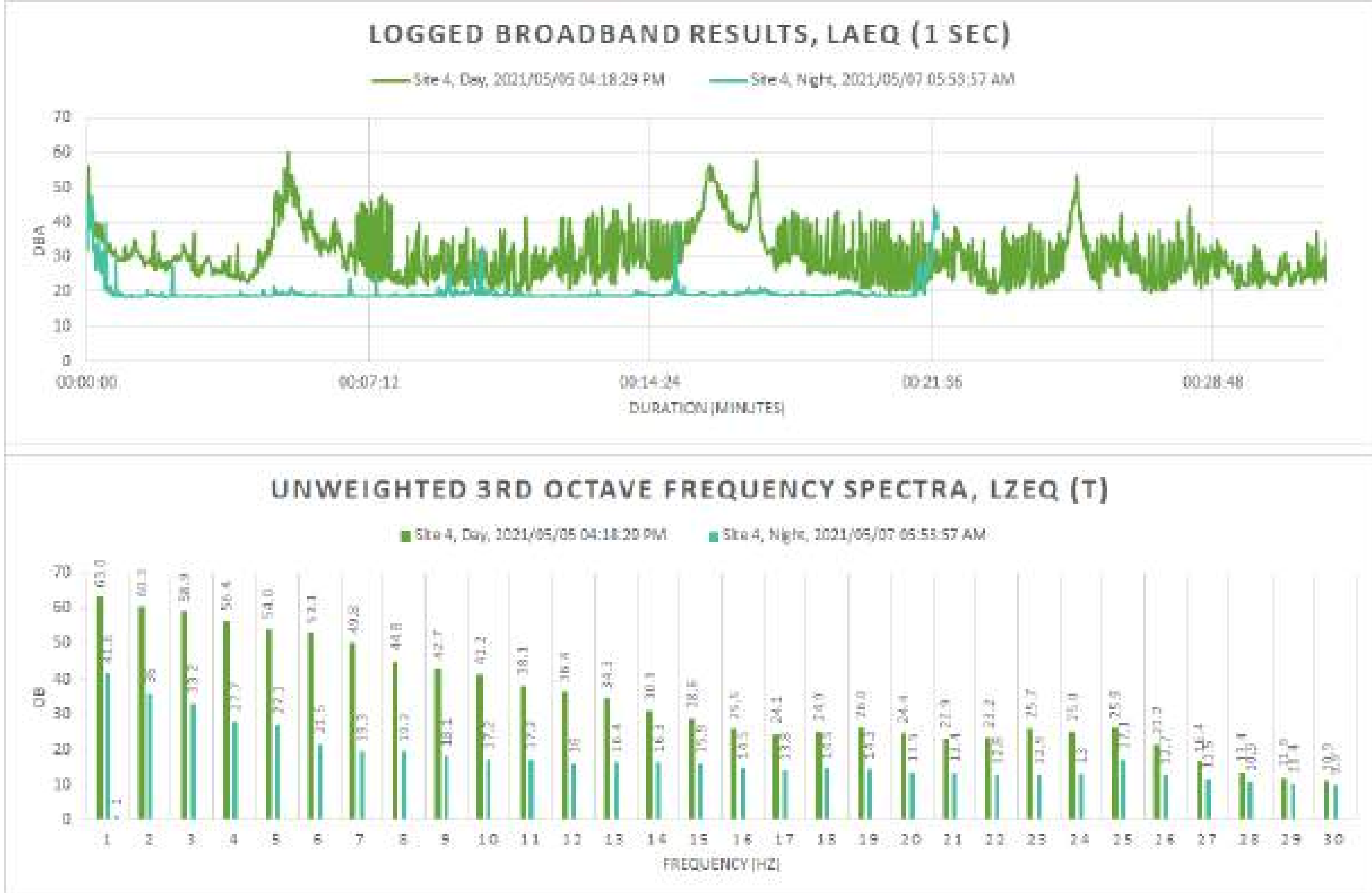


Figure 20: Detailed survey results for Site 4

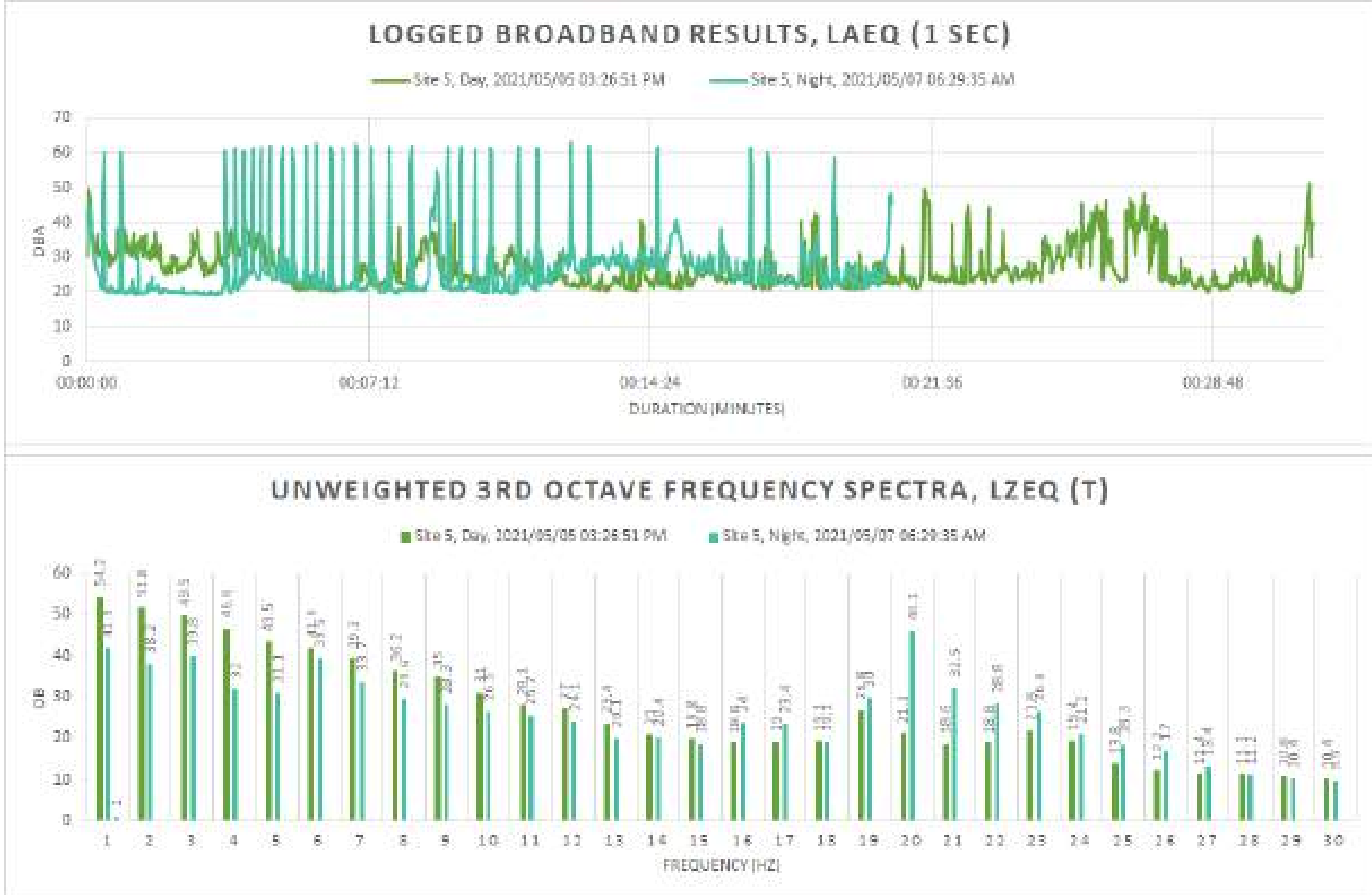


Figure 21: Detailed survey results for Site 5

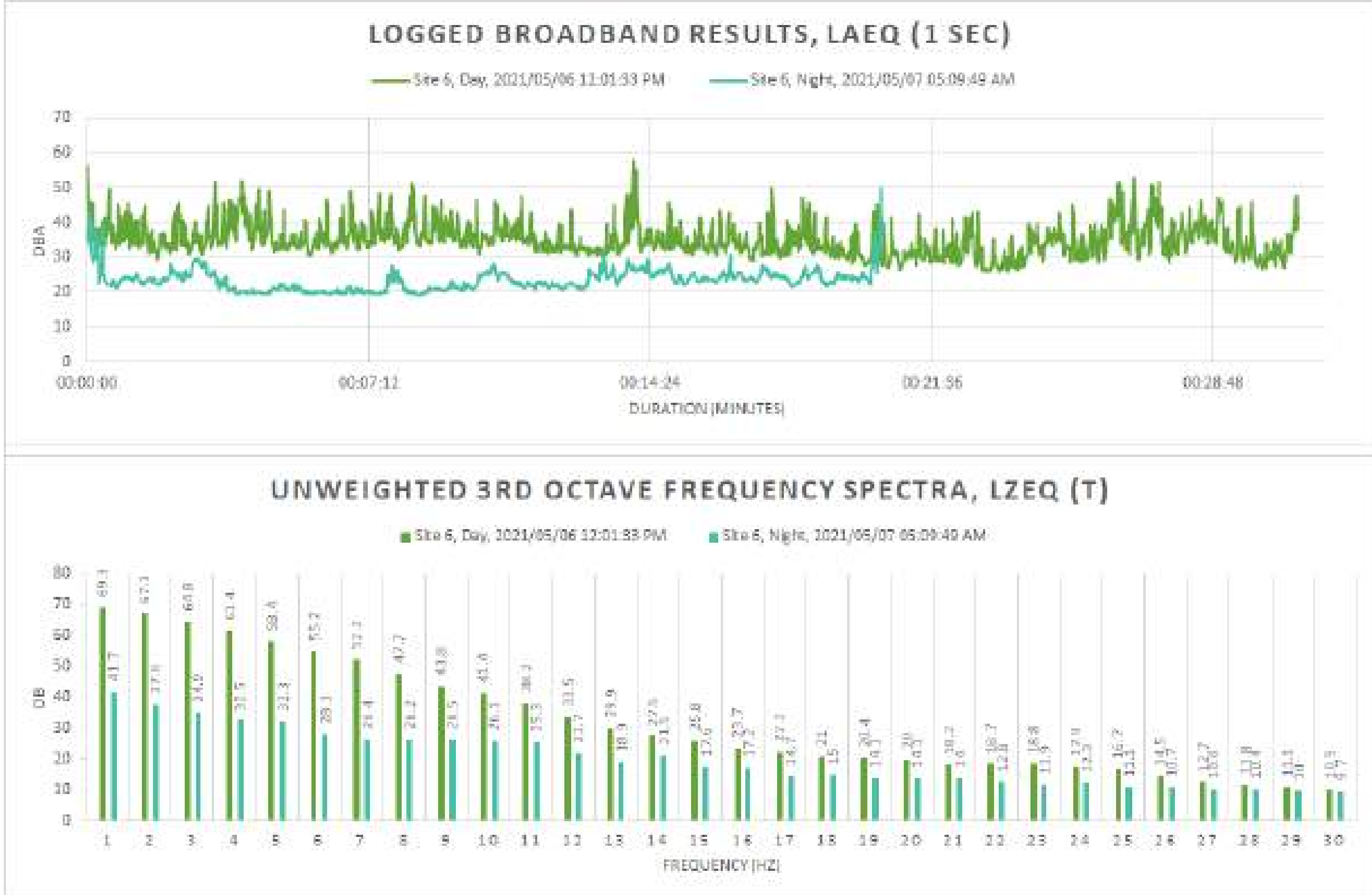


Figure 22: Detailed survey results for Site 6

Appendix E – Site Photographs

Facing north

Facing east

Facing south

Facing west

Figure 23: Photographs of environmental noise survey Site 1

Facing north

Facing east

Facing south

Facing west

Figure 24: Photographs of environmental noise survey Site 2

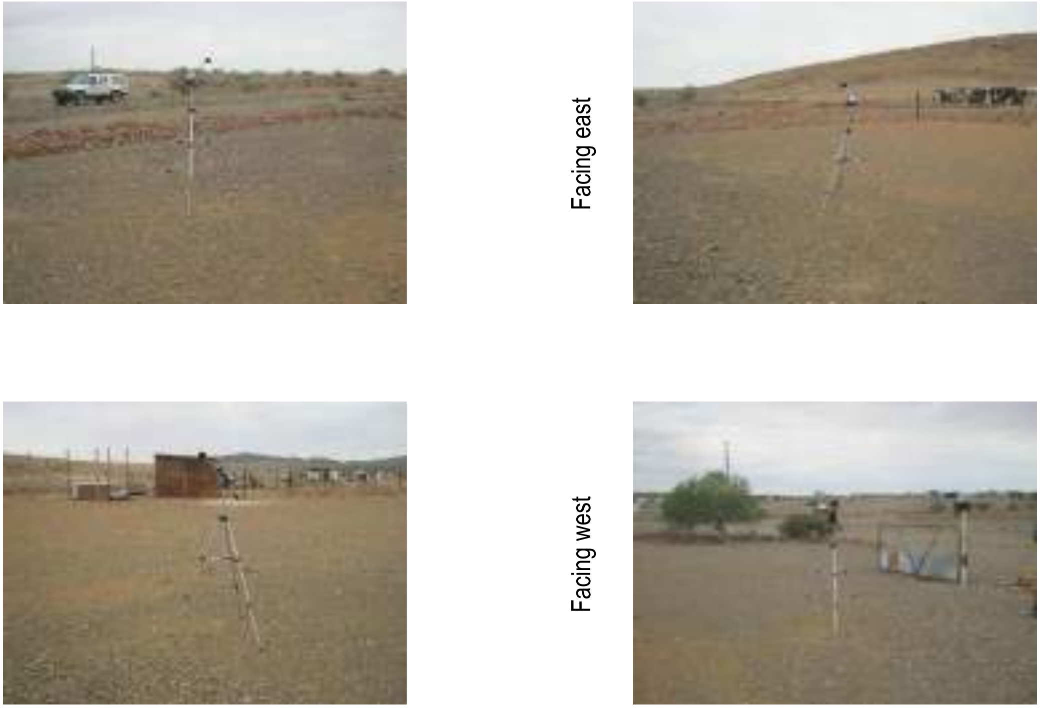


Figure 25: Photographs of environmental noise survey Site 3

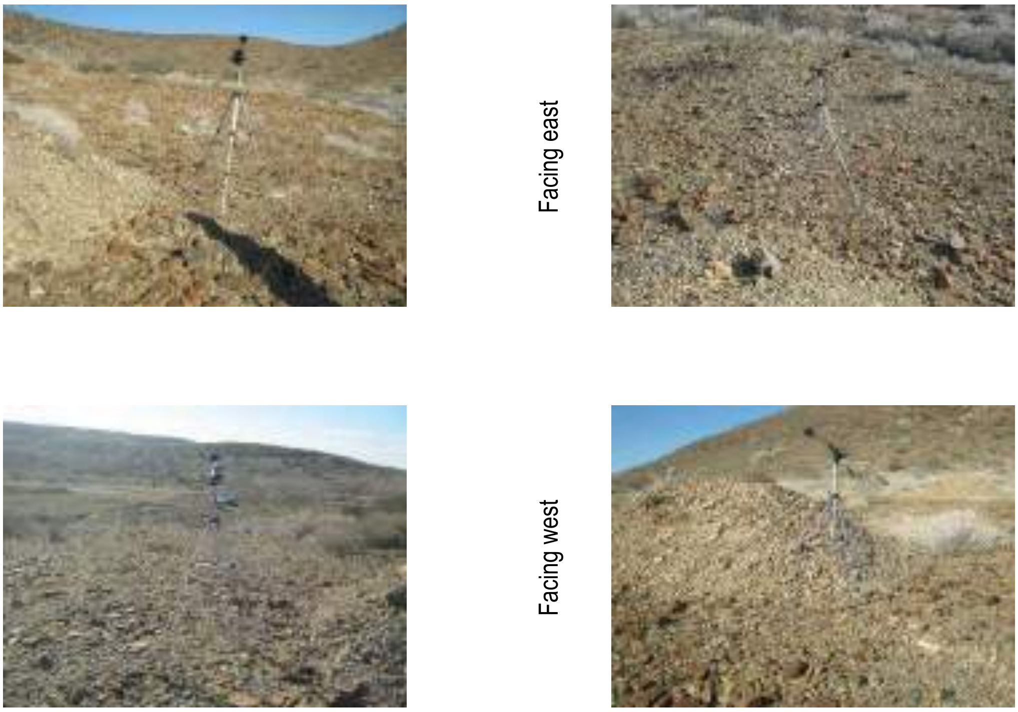


Figure 26: Photographs of environmental noise survey Site 4

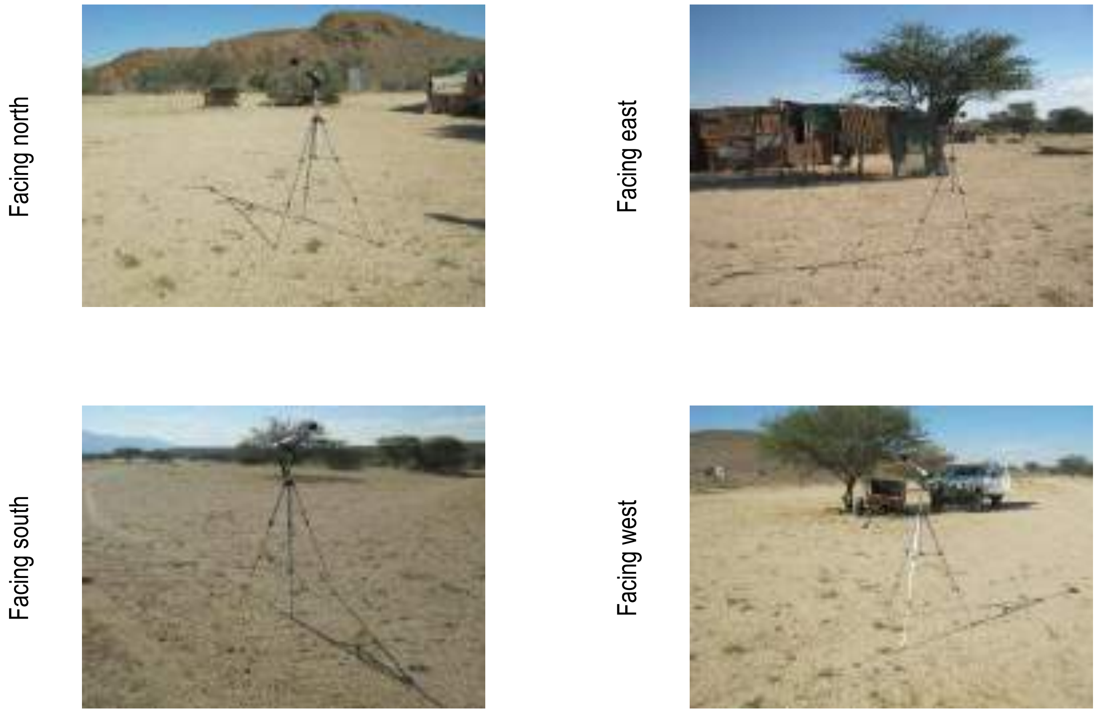


Figure 27: Photographs of environmental noise survey Site 5

Figure 28: Photographs of environmental noise survey Site 6

INNOVATIVE TRANSPORT SOLUTIONS

29 De Havilland Cres.
Pro Park, Building 1
Persequor Technopark
Pretoria 0020
+27 (012) 349 1664
gauteng@itsglobal.co.za

5th Floor, Imperial Terraces
Carl Cronje Drive,
Tyger Waterfront
Bellville 7530
+27 (021) 914 6211
westerncape@itsglobal.co.za

www.itsglobal.co.za

To: Environmental Compliance Consultancy (ECC) – Mr Lester Harker

From: Christoff Krogscheepers, Hugo Engelbrecht and Alain Rousseau

Date: 15 December 2021

Reference: ITS 4427

Subject: **Transport scoping report for the Uis Afritin mine, in the Erongo region of Namibia**

1 Introduction

This scoping report outlines the existing operations of the Afritin tin mine in Uis, as well as aspects that should be evaluated in a future detailed Transport Impact Assessment (TIA) as part of the proposed expansion of this mine. The mine is located southeast of the town Uis, in the Erongo region of Namibia. The main roadways in the site vicinity include the C35, which connects Uis with Hentiesbaai, and the C36, which connects Uis with Omaruru. The mine is located south of these two roads. See **Figure 1** for the Regional Map and **Figure 2** for the Locality Plan below.

Figure 1: Regional Map

Figure 2: Locality Plan

2 Surrounding Roads

The C35 and C36 are single carriageway roads with a posted speed limit of 100km/h. The majority of these roads are gravel, however certain sections near the towns are constructed with pavement layers and an asphalt surfacing.

The section of the C36 between the Uis Main Road and D3714 intersections, is constructed and surfaced with asphalt. The width of this asphalt surface is approximately 7,0 meters wide. The C35 is mostly a gravel road, however about 20km outside of Hentiesbay it is constructed with pavement layers and surfaced with asphalt.

The condition of the C36 road, near the development, is in a relative poor condition with various spots of cracking and failure. There are various reasons for this type of failure to occur, but the most likely cause is that the traffic load exceeds the design capacity of the roadway as well as excessive travel speeds. It is recommend that the road be upgraded and resurfaced from a safety as well as a maintenance point of view. This upgrade should be about 1km in length along the C36 roadway (500 meters on east and west side of the mine access) and should be funded by the developer.

3 The Development

This Afritin mine, excavates and process Tin (Sn) that gets transported to Walvis Bay via the C36, C35 and C34. The current operational hours of this mine is 3, 8 hour shift per day 7 days a week.

The existing tin mine throughput production is approximately 80 tonnes of tin raw material per hour (which produces approximately 65 tonnes of tin final product per month). As part of the next phase of production, it is planned to increase the total throughput by approximately 50% to 120 tonnes of tin per hour (or approximately 100 tonnes of tin per month). This will be achieved by:

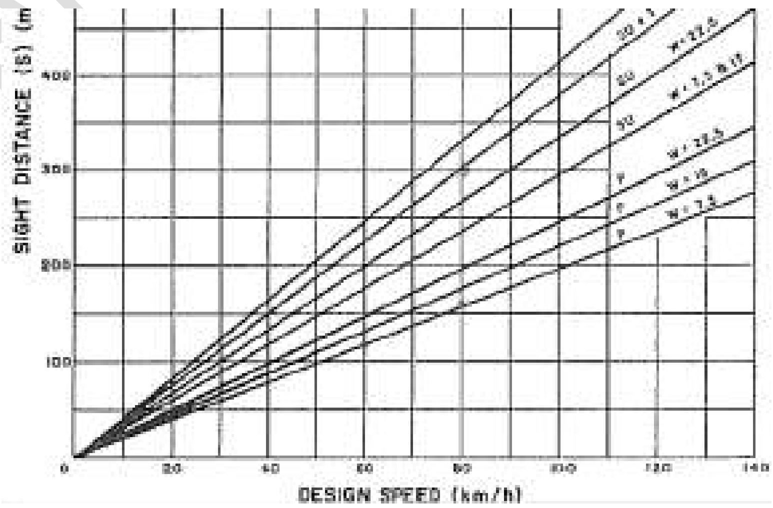
- *Modular expansion of individual circuits,*
- *Improve overall recovery of tin from 60% to 70%, and*
- *Improve overall recovery of tantalum from 15% to 30% (improved magnetic separation).*

4 Site Access

The existing site access is located along the C36 roadway. The nearest access to the Tin Mine development is approximately 265 meters to the east along C36. The control at the mine access is free flow along the C36 and stop/priority controlled on the development exit.

There is a boom controlled access along this access road, it is located approximately 500 meters south of the C36 / mine access intersection. The mine used to have a secondary access along the C36, however this access is no longer in use. This secondary access was located approximately 420 meters west from the existing mine access.

Based on video site drive, there were no posted speeds along the C36 roadway for more than a kilometre from the mine access. With the current speed limit of 100km/h along the C36, the required Shoulder Sight Distance at the mine exit should be 200 meters for cars and 300 meters for a single unit truck (based on the Urban Transport Guidelines UTG 1).



The available SSD at this exit is approximately 240 meters, which is sufficient for cars, but it is insufficient for trucks. In order to improve the safety at this exist, it is recommended to reduce the posted speed limit along the C36 at the mine exit to 80km/h, for at least 1km on either side of the mine access intersection. The required SSD for an 80km/h design speed environment is 240 meters for trucks. With this reduced posted speed limit along the C36 to 80km/h, sufficient SSD would be available.

See **Figure 3** and **Photos 1-2** below for the available Shoulder Sight Distance (SSD).

Figure 3: Shoulder Sight Distance Main Access

<table>
<tr><th colspan="2">Main Development Access</th></tr>
<tr><td>
Photo 1: Eastbound view</td><td>
Photo 2: Westbound view</td></tr>
</table>

Street lighting should be installed to improve the safety near the mine access especially at night as the mine operates 24 hours a day 7 days a week and the lighting also provides an easier identification of where the mine is located at night.

5 Existing Operations

The C36 / mine entrance intersection is a "T" intersection, with free flow along the C36 and a stop control on the mine exit, and a single lane on each approach. See **Figure 4** below for the existing lane configuration and traffic control.

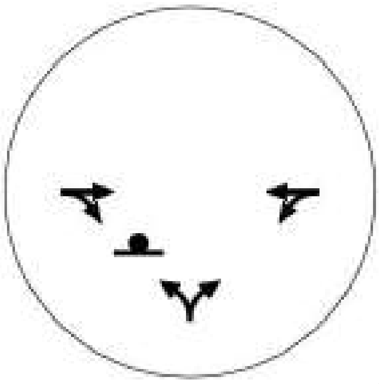


Figure 4: Existing Geometry

The C36 / mine access intersection were surveyed /counted on 18 November 2021. The 2021 Existing Traffic conditions is based on the current intersection geometry / control, as well as the existing traffic volumes. Based on the Existing Traffic capacity analysis results, this intersection currently operates acceptably, from a capacity analyses point of view, with the following results:

- *Level of Service (LOS) A during all peak periods,*
- *Delays less than 10 seconds average during peak periods, and*
- *Volume to Capacity (v/c) ratio less than 5 percent during peak periods.*

The volume to capacity ratio is an indication whether an intersection is operating under- or over capacity. With a very low v/c ratio of less than 5 percent, it means that there is more than 95 percent *spare* intersection capacity currently available. See **Figure 5** for the existing traffic conditions for the weekday AM, Midday and PM peak hours respectively.

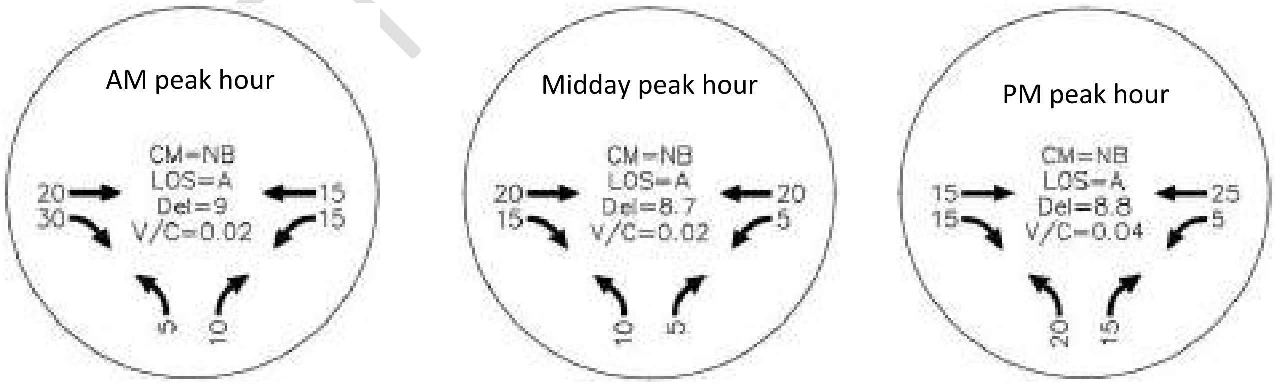


Figure 5: Existing Traffic Operations (***CM = Critical Movement***)

A separate right turn lane to improve safety conditions at this intersection was also evaluated but based on the Access Management Guidelines (AMG) the separate right turn lane is not warranted. It is however recommended to upgrade and re-surface this existing intersection, in order for appropriate road markings and signs to be implemented.

6 Heavy Vehicles

The current heavy vehicle percentage at the C36 / mine access varies between 4 / 3 percent during the weekday AM / PM peak periods respectively, with 6 percent during the weekday midday peak periods. Currently there is about 12 trucks a day that travel to the C36 / Tin Mine access intersection, of which 4 trucks (30%) enter / leave the Mine. It is expected, with the development upgrades for the mine, the trips will likely increase by approximately 2 additional trucks. This will be evaluated in more detail in the TIA.

7 Public Transport

The current public transport percentage (i.e. Buses) at the C36 / mine access varies between 13 / 11 percent during the weekday AM / PM peak periods respectively. Currently there is about 31 buses a day that travel to the C36 / Tin Mine access intersection, of which 17 buses (55%) enter / leave the Mine.

8 Pedestrians

Near the mine access, the C36 roadway is generally a straight road with a minimum shoulder sight distances of 200 to 250 meters for the pedestrians. Currently more than 250 meters shoulder sight distance is available. Pedestrians may easily cross the C36 roadway due to the low volumes of vehicles travelling along the C36 (less than 100 vehicles in an hour). Pedestrians can walk along C36 roadway in the wide gravel shoulders which is approximately 4 meters wide.

9 Future Operations

This mine currently produces 65 tons of tin final product per month (or 780 tons per annum). It is planned to increase production at this mine to 100 tons of tin per month (or 1 200 tons per annum), which is an approximate increase of 50 percent, based on the current production rate. This scoping report evaluates the impact on the external road network. With this increase in production, it is expected that the trips on the external road network could also increase by as much as 50 percent per day, relative to the current traffic volumes.

The expected impact from this increase in development trips will be evaluated in a full Transport Impact Assessment (TIA) that would be completed early in 2022.

10 Conclusions and Recommendations

This scoping report outlines the existing operations of the Afritin tin mine in Uis, as well as aspects that should be evaluated in a future detailed Transport Impact Assessment (TIA) as part of the proposed expansion of this mine.

The mine is located southeast of the town Uis, in the Erongo region of Namibia. The main roadways in the site vicinity include the C35, which connects Uis with Hentiesbaai, and the C36, which connects Uis with Omaruru.

Surrounding Roads: The condition of the C36 roadway, near the development, is in a relative poor condition with various spots of cracking and failure. It is recommend that the road be upgraded and resurfaced from a safety- as well as a maintenance point of view. This upgrade should be funded from the developer and the upgrade should be approximately 500 meters on the east and west sides of the mine access along C36.

The Development: The existing tin mine currently produces 65 tonnes of tin per month. As part of the next phase of production, it is planned to increase the output by 50% to 100 tonnes of tin per month.

Site Access: It is recommended to reduce the posted speed limit along the C36 in the vicinity of the mine exit to 80km/h, for at least 1,0km on either side of the mine exist. The required SSD for an 80km/h design speed environment is 240 meters for trucks. With this reduced posted speed limit along the C36 to 80km/h, sufficient SSD would be available. Street lighting should be installed to improve safety near the mine access and this also provides an easier identification of where the mine is located at night.

Existing Operations: The C36 / mine access intersection currently operates acceptably, from a capacity analyses point of view. However, it is recommended to upgrade and re-surface this intersection, in order for appropriate road markings and signs to be implemented.

Heavy Vehicles: Approximately 4 trucks enter / leave the site per day. This is about 30 percent of trucks per day from the total traffic at the C36 / mine access intersection.

Public Transport: Approximately 17 buses enter / leave the site per day. This is about 55 percent of buses per day from the total traffic at the C36 / mine access intersection.

Pedestrians: A minimum of 250 meters shoulder sight distance is available and pedestrians can easily cross the roadway as there is less than 100 vehicles in an hour travelling along C36. Pedestrians can walk along C36 roadway in the wide gravel shoulders which is approximately 4 meters wide.

Future Operations: The expected impact from this increase in development trips on the C36 / mine access intersection will be evaluated in a full Transport Impact Assessment (TIA) that would be completed in early 2022.

Based on the findings in this scoping report, it is evident that the C36 / mine access intersection currently has sufficient spare capacity. However, the upgrades as discussed above are recommended to ensure safer access operations. The details of these upgrades would be finalised as part of the full Transport Impact Assessment (TIA) that would be completed in early 2022.

Reference

1. *Committee of Transport Officials. South African Traffic Impact and Site Traffic Assessment Standards and Requirements Manual. TMH 16 vol 2. 2014*
2. *South African Trip Data Manual, TMH17, Version 1.1, COTO, September 2013*
3. *Western Cape Government, Access Management Guidelines, November 2019*
4. *Afritin Mining Limited. Uis Tin Mine, Phase 1 Fast Tracked Stage II Definitive Feasibility Study. Minxcon reference: P2020_030a. April 2021*

Uis Afritin Mine

Transport Impact Assessment (TIA)

Erongo Region, Namibia

Report Status – **Final**

Date - **August 2022**

5th Floor

Imperial Terraces

Carl Cronje Drive

Tyger Waterfront

Bellville, 7530

Tel: 021 914 6211

e-mail: westerncape@itsglobal.co.za

SUMMARY SHEET

Report Type	Transport Impact Assessment (TIA)
Title	Uis Afritin Mine
Location	Erongo Region, Namibia
Client	Environmental Compliance Consultancy (ECC)
Reference Number	ITS 4427
Project Team	Christoff Krogscheepers Hugo Engelbrecht Alain Rousseau
Contact Details	Tel: 021 914 6211
Date	August 2022
Report Status	Final
File Name	G:\4427 TIA Uis Afritin Mine, Erongo\12 Report\Issue\4427_TIA Uis Afritin Mine_table report_AR_2022-08-03.docx

It is herewith certified that this Traffic Impact Assessment has been prepared according to requirements of the South African Traffic Impact and Site Traffic Assessment Manual.

TABLE OF CONTENTS

REPORT - SUMMARY TABLE

This transport impact assessment is reported only in a summary table instead of a lengthy report to assist review and interpretation of the results. This summary table includes all the relevant information that is normally contained in a report. It should be sufficient for review and interpretation of the expected transport impacts as well as the comprehension of the required measures to mitigate the transport impact. If any more detail is required, please contact the authors.

ANNEXURES

Transport Impact Assessment

Uis Afritin Mine, Erongo Region, Namibia

1 Purpose of Study	This report summaries an investigation of the transport impacts expected as part of the Afritin Mine development in Uis. The purpose of this assessment is to identify constraints within the surrounding road network and recommend appropriate mitigation measures.
2 Locality	The Afritin mine development is located in Uis, which is in the Erongo region of Namibia. This mine is north of Hentiesbaai and west of Omaruru. The site is south of the C36 Roadway in Uis. See **Figure 1** and **Figure 2** in Annexure A for the Regional- and Local Locality Maps respectively.
3 Land Use & Extent	**Existing land use:** Currently a Tin Mine The existing land use will remain un-changed. However, it is planned to increase the production of tin at this mine. This increase in production would be achieved by increasing throughput production from 80 tonnes per hour to 120 tonnes per hour of raw material, by the: • modular expansion of individual circuits, • improving the overall recovery of tin from 60% to 70%, and • improving the overall recovery of tantalum from 15% to 30% The additional truck load of raw material being delivered to the site is approximately 2000 tonnes per month.
4 Existing Access	The existing site access is located along the C36 roadway. The closest existing intersection to the development access is located approximately 265 meters to the east along C36. The control at the mine access is free flow along the C36 and stop/priority controlled on the development exit. There is a boom-control along this access road at the mine access, which is located approximately 500 meters south of the C36 roadway. The mine used to have a secondary access along the C36, however this access is no longer in use by the mine. This secondary access was located approximately 420 meters west from the existing mine access. The current speed limit along the C36 roadway is 100km/h. The required Shoulder Sight Distance (SSD) for this operational speed, is 200 meters for cars and 300 meters for a single unit truck (Urban Transport Guidelines UTG 1).

See **Image 1** below for the required Shoulder Sight Distance for various travel speeds.

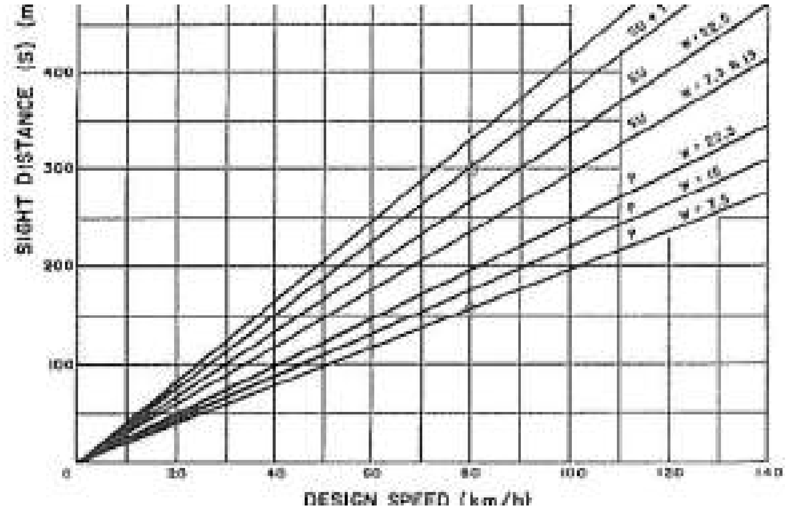


Image 1: *UTG 1, Shoulder Sight Distance*

The available SSD at this exit is approximately 240 meters, which is sufficient for cars, but it is insufficient for trucks. To improve the safety at this exit, it is recommended to reduce the speed limit along the C36 at the mine exit to 80km/h, for at least 1,0km on either side of the mine access intersection. The required SSD for an 80km/h design speed environment is 240 meters for trucks. With this reduced speed limit along the C36 to 80km/h, sufficient SSD would be available.

See **Image 2** and **Photos 1-2** below for the available Shoulder Sight Distances (SSD's).

Image 2: *Shoulder sight distance Main access*

<table>
<tr>
<td></td>
<td>
<table>
<tr><td colspan="2">Main Development Access</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Photo 1: Eastbound View</td><td>Photo 2: Westbound View</td></tr>
</table>
Street lighting is recommended at the mine access to improve safety at this intersection during night times and / or low light conditions.
</td>
</tr>
<tr>
<td>5 Existing Roadways</td>
<td>
The major roads within the site area, are the C35 and C36 Roadways.

The C35 and C36 are single carriageway roads with a posted speed limits of 100km/h. These roads are mainly gravel, however certain sections near the towns are constructed with pavement layers and road surfacing.

The section of the C36 between the Uis Main Road and D3714 intersections, is constructed and surfaced. The width of this surfaced road is approximately 7,0 meters. The C35 is mostly a gravel road, however about 20km outside of Hentiesbaai it is constructed with pavement layers and road surfacing.

The condition of the C36 road, near the development, is in a relatively poor condition with various spots of cracking and pavement failure. There are various reasons for this type of failure, but it is most likely due to excessive truck loads and excessive travel speeds. It is recommended that the road be upgraded and resurfaced from a safety as well as a maintenance point of view. This upgrade should be for about 1,0km total length along the C36 roadway (i.e. 500 meters either side to the mine access) and should it should be funded by the developer.
</td>
</tr>
</table>

6 Study Intersection	Int. 1: C36/ Mine Access Priority Stop Control The C36 / Mine Access intersection is a "T" intersection, with free flow along the C36 and a stop control on the mine exit, and a single lane on each approach. See **Figure 3** for the existing lane configuration and traffic control.
7 Analyses Hours	Weekday AM peak hour (Surveyed peak hour 06:45 to 07:45) Weekday Midday peak hour (Surveyed peak hour 13:30 to 14:30) Weekday PM peak hour (Surveyed peak hour 17:00 to 18:00) The peak hours were determined from the peak period traffic counts
8 Scenarios Analysed	**Scenario 1**: 2021 Existing Traffic conditions. Based on existing geometry and traffic volumes. See **Section 9** of this report for details. **Scenario 2**: 2026 Background Traffic conditions (Based on **Scenario 1** traffic volumes, escalated with a 3% growth rate per year.) Refer to **Section 10** for details. **Scenario 3**: 2026 Total Traffic conditions (Based on **Scenario 2** traffic volumes, *PLUS* the additional trips for the proposed mine expansion). Refer to **Section 13** for details. Intersection analyses were done with Traffix version 8.0 Software, which is based on the Highway Capacity Manual (HCM).
9 Existing Intersection Operations	The C36 / mine access intersection was surveyed / counted in November 2021. The current production rate at this mine is 65 tons of tin (final product) per month (or 780 tons per annum). The 2021 Existing Traffic conditions is based on the current intersection geometry / control, as well as the existing traffic volumes. The following can be concluded based on the capacity analysis results: o Level of Service (LOS) A during all peak periods, o Delays less than 10 seconds average during peak periods, and o Volume to Capacity (v/c) ratio less than 5 percent during peak periods. Hence, more than 95% spare capacity available. Based on the existing capacity analyses results, the study intersection operates acceptably. Hence, no upgrades are required / proposed, from a capacity analyses point of view. See **Figure 3** for the Existing Traffic volumes and operations for the weekday AM, Midday and PM peak hours respectively.

10 Background Traffic Conditions

The 2026 Background Traffic conditions is based on the current intersection geometry / control. The traffic volumes are based on existing traffic counts, escalated with a 3% growth rate per year. The following can be concluded based on the capacity analysis results:

- Level of Service (LOS) A during all peak periods,
- Delays less than 10 seconds average during peak periods, and
- Volume to Capacity (v/c) ratio less than 5 percent during peak periods. Hence, more than 95% spare capacity available.

Based on the Background Traffic capacity analyses results, the study intersection would continue to operate acceptably. Hence, no upgrades are required / proposed, from a capacity analyses point of view.

See **Figure 3** for the Background Traffic volumes and operations for the weekday AM, Midday and PM peak hours respectively.

11 Trip Generation Rates and Development Trips

No trip generation data is available (in COTO- or ITE manuals) for mines, since there are various factors that affects the number of trips (including size, process, and procedures of what is being mined).

The AfriTin mine is currently operational with a monthly production rate of approximately 65 tonnes of tin (80 tonnes per hour of raw material equates to approximately 65 tonnes of tin final product per month) which is expected to increase to 100 tonnes of tin final product per month. This is an approximate increase of 50% in production. Based on the above, the current vehicular trips were also increased by 50% to determine the expected additional trips as part of the increase in production. See **Table 1** for the expected additional development trips.

Table 1: Development Trips per Peak Hour

Existing 65 tonnes per month (production)			
	AM Peak	Midday Peak	PM Peak
Total entering	47	21	18
Total exiting	13	18	34
Expected 100 tonnes per month (production)			
	AM Peak	Midday Peak	PM Peak
Total entering	74	33	28
Total exiting	21	29	53
Expected Additional Trips			
	AM Peak	Midday Peak	PM Peak
Total entering	27	12	10
Total exiting	8	11	19

See **Figure 4** in Annexure A for the development trips.

	See **Table 2** below for the additional truck trips for the raw materials being transported to the site. *Table 2: Raw Material Truck Trips* 2000 tonnes — Per Month 20 tonnes — Truck carry capacity 100 Trips — Per Month Assume the Tin mine operates for 6 days a week (About 24 days a month) Approximately 5 Trips — Per Day
12 Trip Distribution	The expected directional distribution of additional development trips was based on the existing peak hour trips / split. This was typically a 60%-40% split, with 60% of vehicles traveling westbound (towards Uis from the site) and 40% traveling eastbound towards Omaruru. See **Figure 4** in Annexure A for the trip distribution.
13 Total Traffic Conditions	The 2026 Total Traffic conditions is based on the current intersection geometry / control, and the traffic volumes are based on the Background Traffic volumes plus the additional development trips from the planned mine expansion. The following can be concluded based on the capacity analysis results: o Level of Service (LOS) A during all peak periods, o Delays less than 10 seconds average during peak periods, and o Volume to Capacity (v/c) ratio less than 5 percent during peak periods. Hence, more than 95% spare capacity available. Based on the Total Traffic capacity analyses results, the study intersection would continue to operate acceptably. Hence, no upgrades are required / proposed, from a capacity analyses point of view. The intersection was also evaluated to determine if turning lanes would be warranted. Based on the Access Management Guidelines (AMG) it is evident that separate turning lanes would *NOT* be warranted from a safety point of view. However, it is recommended to upgrade and re-surface the C36 at the mine access intersection for at least 500 meters to both sides of the intersection along the C36 as well as at along the access road for at least 50 meters, to include appropriate road markings and signage, that would ensure improved intersection safety. See **Figure 3** for the Total Traffic scenario conditions for the weekday AM, Midday and PM peak hours respectively.

14 Heavy Vehicles	The current heavy vehicle percentage at the C36 / mine access varies between 4 / 3 percent during the weekday AM / PM peak periods respectively, with 6 percent during the weekday midday peak periods. Currently about 6 trucks enter / exit the mine per day. As part of the proposed increase in production at the mine, the number of heavy vehicles is expected to increase to 10 truck trips per day. With an additional 5 trips per day for transporting the raw material to site.
15 Public Transport	The current public transport percentage (i.e. Buses) at the C36 / mine access varies between 13 / 11 percent during the weekday AM / PM peak periods respectively. Currently there is about 49 bus trips a day that travel through the C36 / Tin Mine access intersection, of which 35 bus trips (70%) enter / leave the mine.
16 Pedestrians	The C36 roadway is relatively straight, with sufficient Shoulder Sight Distance for pedestrians to cross the road safely, in the vicinity of the mine access. Currently more than 250 meters shoulder sight distance is available. Pedestrians can also easily cross the C36 roadway due to the low traffic volumes along the C36 (less than 100 vehicles in an hour). Pedestrians can also walk along C36 roadway in the wide gravel verge which is approximately 4 meters wide.
17 Conclusion & Recommendations	This report summaries an investigation of the transport impacts expected as part of the Afritin Mine development in Uis. The following can be concluded based on the findings in this investigation: **Existing Traffic:** The study intersection currently operates acceptably. Hence, no road upgrades are proposed / required from an intersection capacity point of view. **Background Traffic:** The study intersection would continue to operate acceptably. Hence, no road upgrades are proposed / required from an intersection capacity point of view. **Site Access:** It is recommended to reduce the posted speed limit along the C36 in the vicinity of the mine exit to 80km/h, for at least 1,0km on either side of the mine access. Street lighting is recommended at the mine access to improve safety at this intersection during night times and / or low light conditions. **Total Traffic:** The study intersection would continue to operate acceptably. Hence, no road upgrades are proposed / required from an intersection capacity point of view. The additional 5 trips for the transportation of raw materials to site per day will have no major impact to the capacity of the intersection.

	However, it is recommended to upgrade and re-surface the C36 at the mine access intersection for at least 500 meters to either side of the mine access intersection along the C36 as well as along the access road for at least 50 meters, to include appropriate road markings and signage, that would ensure improved intersection safety. Based on the findings in this transport investigation, it is evident that the proposed Uis AfriTin mine expansion could be sufficiently accommodated, provided that the upgrades discussed in this report are in place. Hence, it is recommended that this development expansion be considered for approval, from a transport point of view.

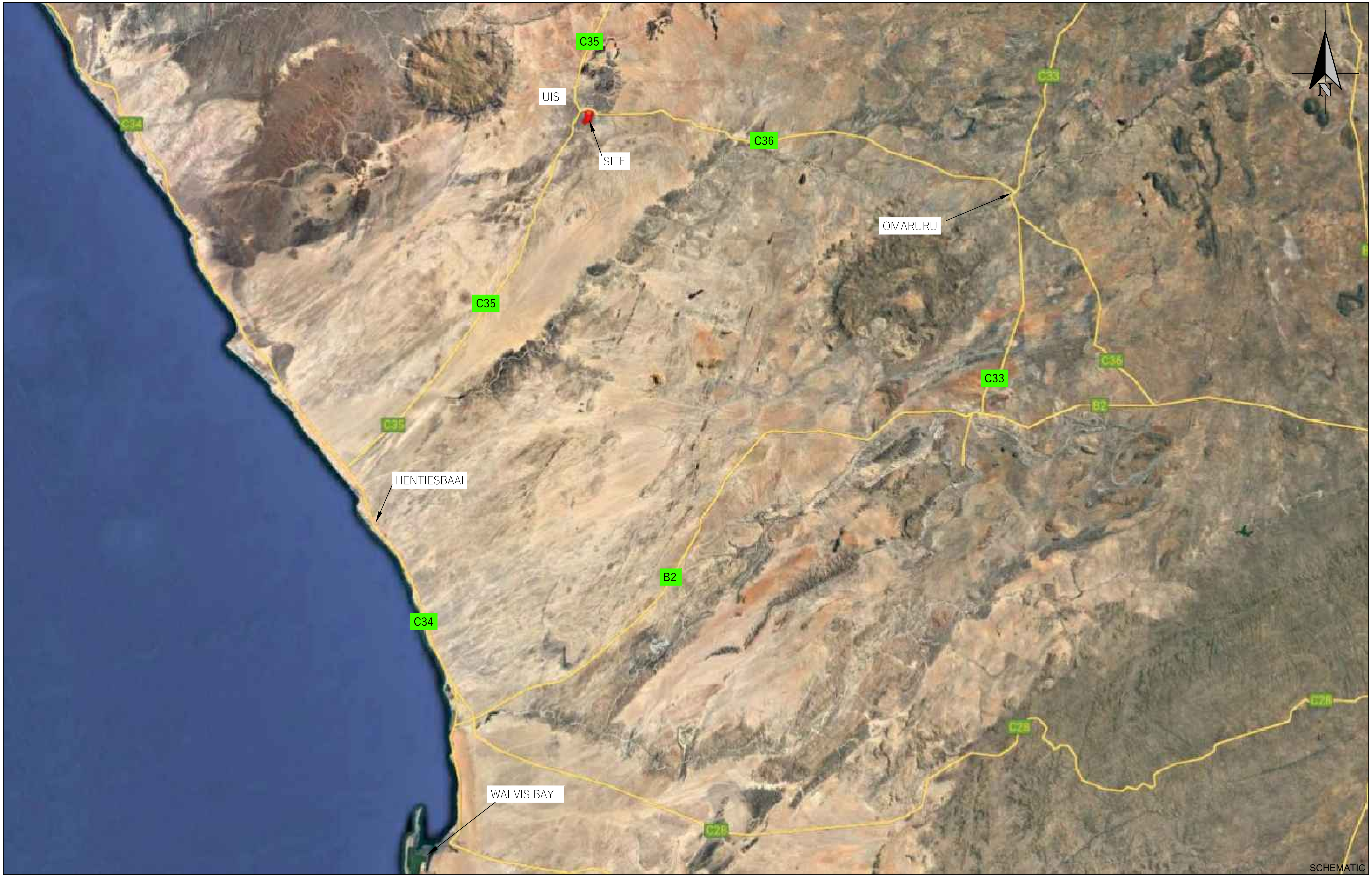
REFERENCES

1. Afritin Mining Limited. Uis Tin Mine, Phase 1 Fast Tracked Stage II Definitive Feasibility Study. Minxcon reference: P2020_030a. April 2021
2. Committee of Transport Officials. South African Traffic Impact and Site Traffic Assessment Standards and Requirements Manual. TMH 16 vol 2. 2014
3. Highway Capacity Manual (HCM), Quality and Level-of-Service Concepts, Transportation Research Board, 9 March 2015
4. South African Road Classification and Access Management Manual, TRH26, Version 1.0, August 2012
5. South African Trip Data Manual, TMH17, Version 1.1, COTO, September 2013

Annexure A

Figures

List of Figures



PROJECT:	FIGURE:	NUMBER:
UIS AFRITIN MINE, TIA	REGIONAL MAP	1

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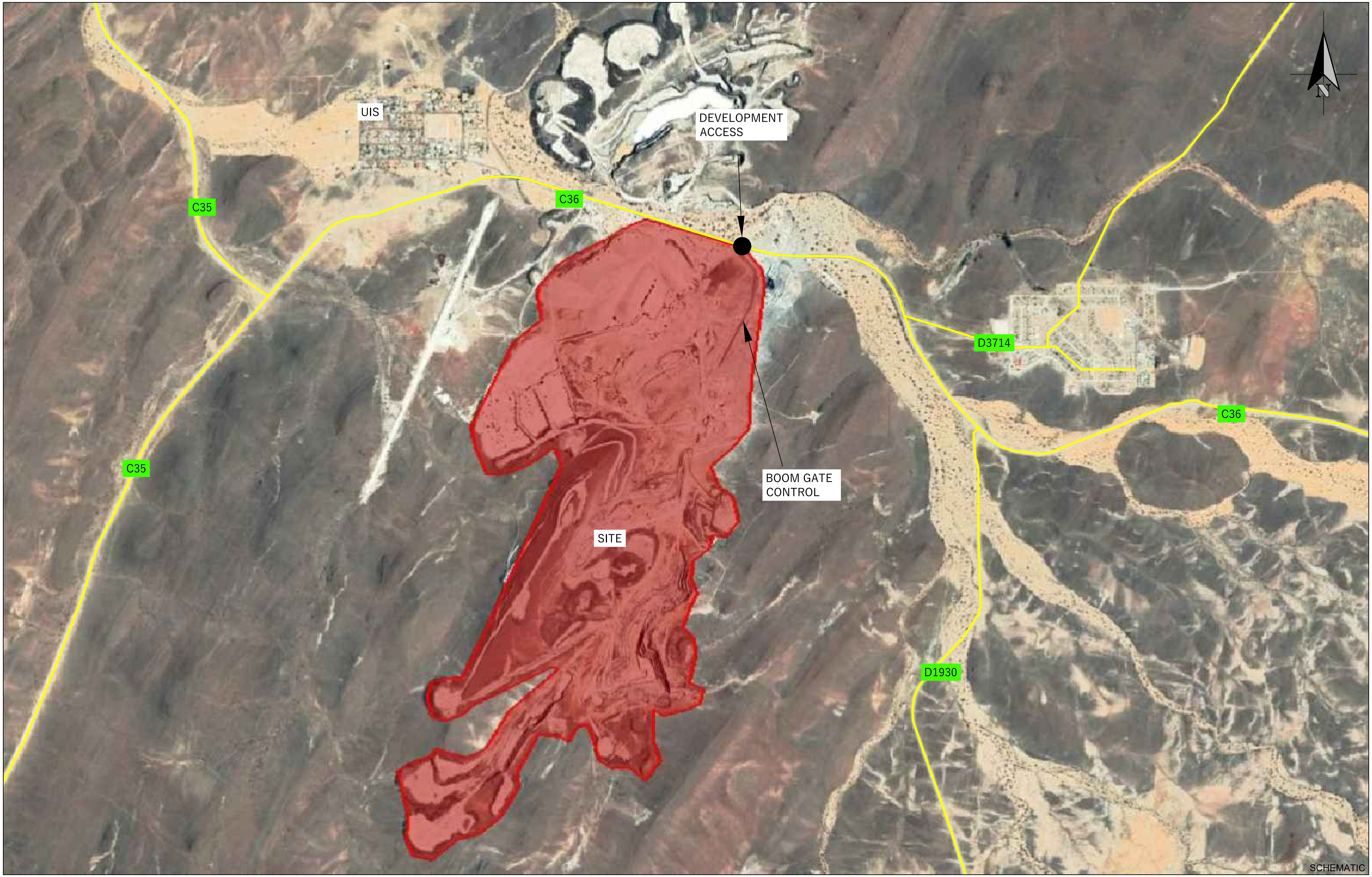

PROJECT:	FIGURE:	NUMBER:
UIS AFRITIN MINE, TIA	LOCALITY PLAN	2

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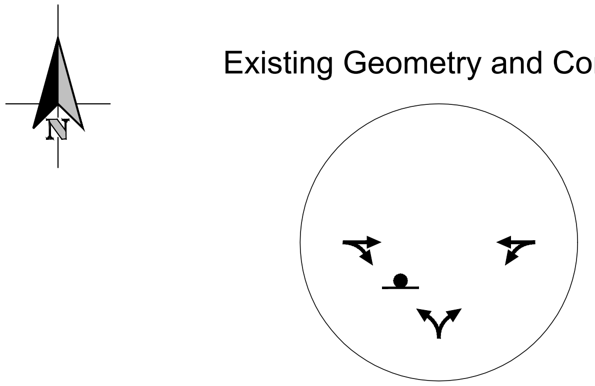
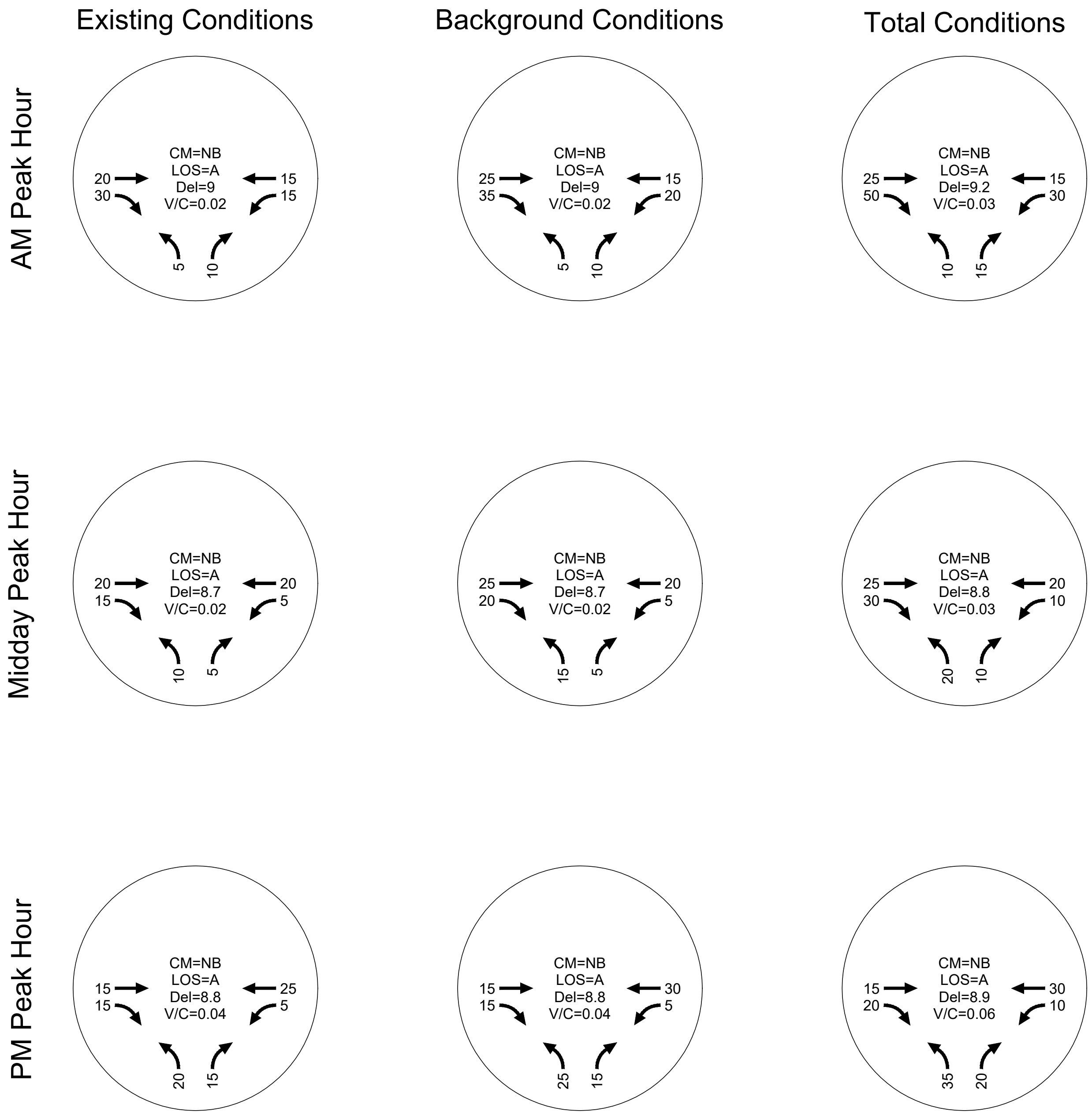


LEGEND
CM = CRITICAL MOVEMENT (UNSIGNALISED) LOS = INTERSECTION LEVEL OF SERVICE (SIGNALISED) / CRITICAL MOVEMENT LEVEL OF SERVICE (UNSIGNALISED) Del = INTERSECTION AVERAGE DELAY (SIGNALISED) / CRITICAL MOVEMENT DELAY UNSIGNALISED V/C = CRITICAL VOLUME-TO-CAPACITY RATIO



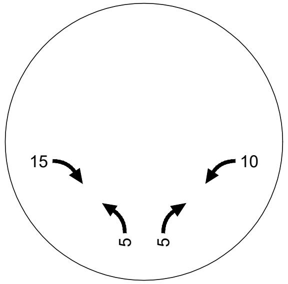
NOTE:
EXISTING TRAFFIC COUNTS: 2021 TRAFFIC COUNTS: ROUNDED TO THE NEAREST 5 veh/h

its

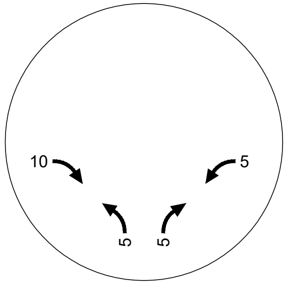
PROJECT: UIS AFRITIN MINE, TIA	NUMBER: 3
FIGURE: ACCESS OPERATIONS AND CONTROLS	

G:\4427 TIA Uis Afritin Mine, Erongo\11 Drawing, Figures & GIS\CAD\4427_UIS Afritin Mine_Traffic figures_AR_2022-02-11.dwg

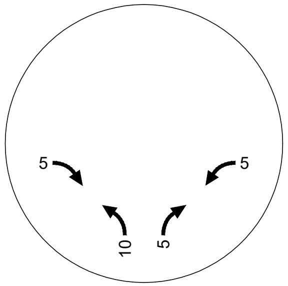
AM Trips

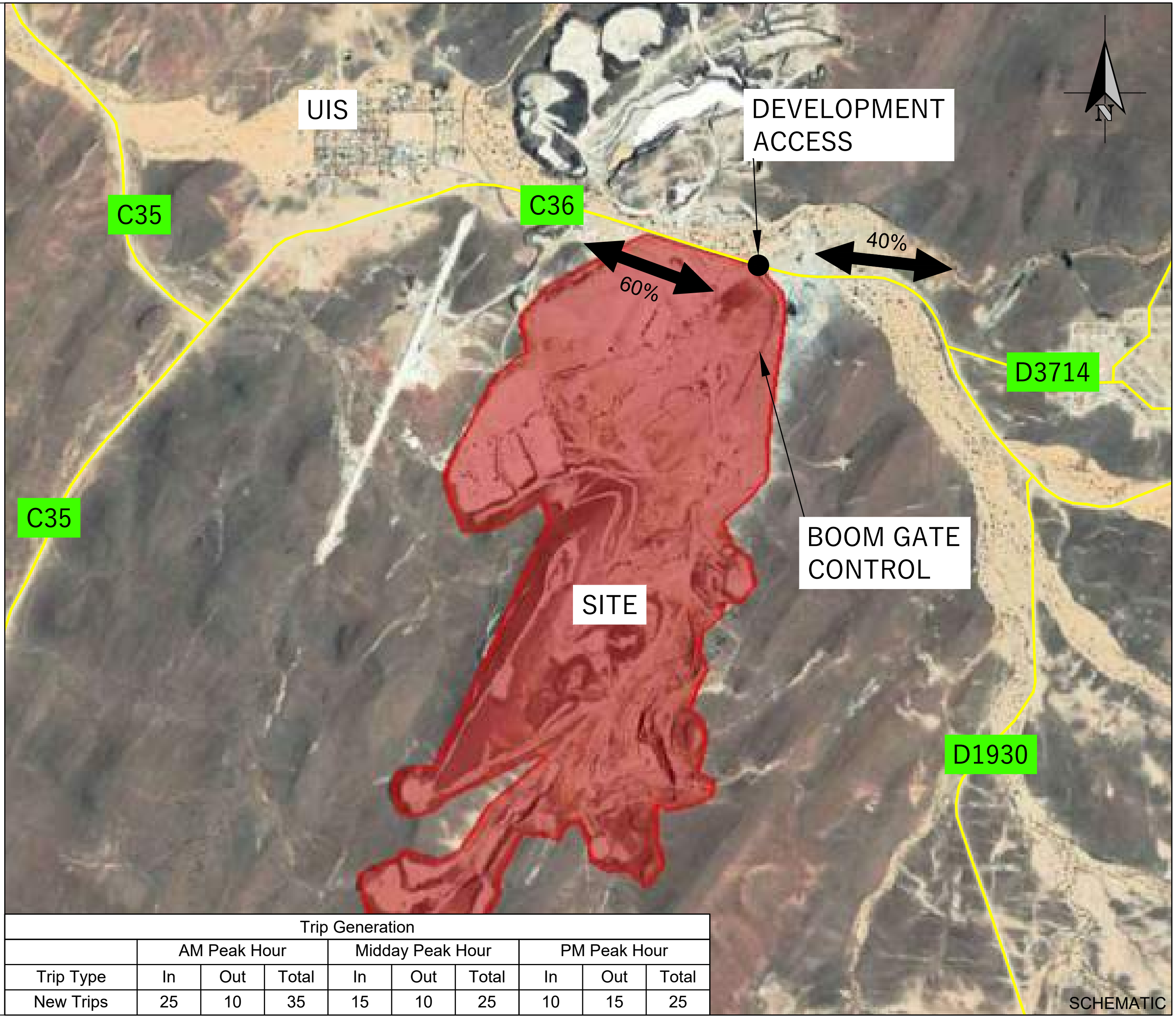


Midday Trips



PM Trips





Trip Generation									
	AM Peak Hour			Midday Peak Hour			PM Peak Hour		
Trip Type	In	Out	Total	In	Out	Total	In	Out	Total
New Trips	25	10	35	15	10	25	10	15	25

PROJECT:	FIGURE:	NUMBER:
UIS AFRITIN MINE, TIA	TRIP GENERATION AND TRIP DISTRIBUTION	4

G:\4427 TIA Uis Afritin Mine, Erongo\11 Drawing, Figures & GIS\CAD\4427_UIS Afritin Mine_Traffic figures_AR_2022-02-11.dwg