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Desktop Groundwater Impact Assessment (DGIA) for the Proposed Exploration Activities on Exclusive Prospecting License (EPL) 5161 near Arandis Town in the Erongo Region

Document Version: **Final**

Proponent: **Best Cheer Investments Namibia (Pty) Ltd**

Date: **01 August 2020**

DOCUMENT INFORMATION

Title: Desktop Groundwater Impact Assessment (DGIA) for the Proposed Exploration Activities on Exclusive Prospecting License (EPL) 5161 near Arandis Town in the Erongo Region

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EXECUTIVE SUMMARY

Best Cheer Investments Namibia (Pty) Ltd (hereinafter referred to as *Best Cheer Investments Namibia* or the *Proponent*) intends to undertake exploration activities on Exclusive Prospecting License (EPL) 5161 near Arandis in the Erongo Region (*the project*). The EPL is located about 15 km northeast of the Arandis Town. And covers a surface area of 5 058 hectares (ha). Potential commodities on EPL 5161 include base and rare metals, dimension stone, nuclear fuel mineral and precious metals. However, for the purpose of this project only dimension stone exploration has been applied for and on which this study has been conducted.

The proposed exploration is however among the listed activities in the Environmental Management Act (EMA) No. 7 of 2007 and its 2012 Environmental Impact Assessment (EIA) Regulations that may not be undertaken without getting the environmental clearance certificate (ECC). Consequently, the Best Cheer Investments Namibia (Pty) Ltd appointed Omavi Geotechnical & Geo-Environmental Consultants CC (hereinafter referred to as *Omavi Consultants*) to undertake the required EIA process and apply for the project ECC.

To ensure that all the significant environmental components are considered as part of the EIA study, Omavi Consultants subcontracted Ms. Fredrika Shagama (an independent Hydrogeologist) to undertake a desktop impact assessment study for one of the physical environmental components (groundwater), i.e. a geohydrological/hydrogeological assessment for the proposed project.

It is for this reason, that this desktop groundwater impact assessment report was compiled. The aim of the report was to determine the possibility/likelihood and extent of groundwater being impacted by the proposed exploration activities, assess the potential impacts, and provide the necessary practical measures to manage avoid and or minimize their significance.

RECOMMENDATIONS AND CONCLUSIONS

The aim of this report was to assess the potential impacts of the proposed exploration activities on the groundwater resources. The assessment has been undertaken on a desktop level, i.e. based on information provided by Omavi Geotechnical & Geo-Environmental Consultants (the project Environmental Assessment Practitioner/Consultant) obtained from their own site visit, information provided by the project proponent, author's professional judgment complemented by experience as well as review of previous relevant studies conducted within proximal distance from the project.

The recommendations provided to the assessment and conclusions made are as follows:

Recommendations

Given the assessment results, to manage and protect the groundwater resources in the project area, the following management measures should be implemented:

Given the assessment results, to manage and protect the water resources, the following management measures should be implemented:

Groundwater Abstraction and Use Mitigation Measures

- **Please note that it is unlikely that a Groundwater Abstraction and Use permit (license) would be required, therefore not significant. This is firstly because the Proponent will not be abstracting water directly from an aquifer but carted to site and secondly during the exploration, the activities will not be yielding any income i.e. not commercially valuable yet. Water use is limited to exploration activities only which is short-term. With this said, it will be very crucial for the Proponent to adhere to the actual water volumes required for the exploration activities even if they will not be abstracting directly from site boreholes.**
- The water user (Proponent) should consider voluntary water use reduction by sticking to the proposed daily threshold volume of **5 m^3 or 5 000 litres, which is 155 000 litres per month (5 000 litres x 31 days = 155 000 litres or 155 m^3). This amounts to 1 860 000 litres or 1 860 m^3 per year (155 m^3 x 12 months).**
- Sufficient water from outside the area should be carted to site on certain days and stored in onsite water tanks. This is to ensure the Proponent's water trucks are not traveling on the local and regional roads everyday which would exert pressure on and impact the services infrastructure such as roads during water transportation. This is to avoid taking from the outside area water supply line in Swakopmund or Karibib in large amounts every day and put unnecessary pressure on the main regional groundwater scheme supplies.
- Given the indication that some abstraction from the saline borehole at Trekkopje mine may occur to supplement carted water for exploration, if ''push comes to shelf'', the water abstracted from the borehole should also be used efficiently and enough should be abstracted just enough to augment the carted water. For instance, if the carted water can supply 3 000 litres (3 m^3) then the borehole can supply the remaining 2 000 litres (2 m^3) of the required volume, but only when deem necessary.
- The Proponent should implement water reuse/recycling methods as far as practicable. Water used to cool off exploration equipment should be captured and used for the cleaning of equipment if possible.
- Water conservation awareness and saving measures training should be provided to all the project workers so that they understand the importance of conserving water and become accountable.

Groundwater Pollution Mitigation Measures

- Exploration site areas where hydrocarbons will be utilized, the surface should be covered with an impermeable plastic liner (e.g. an HDPE liner), carefully placed so as to minimize risk of puncturing, to prevent any spillages from getting into direct contact with the soils and prevent eventual infiltration into the ground.
- Project machines and equipment should be equipped with drip trays to contain possible oil spills when operated during exploration works.
- All wastewater and hydrocarbon substances and other potential pollutants associated with the project activities should be contained in designated containers on site and later disposed of at nearby approved waste sites in accordance with MAWLR's Water Environment Division standards on waste discharge into the environment. This is to ensure that these hazardous substances do not infiltrate into the ground and affect the groundwater quality.
- In cases of accidental fuel or oil spills on the soils from site vehicles, machinery and equipment, the polluted soil should be removed immediately and put in a designate waste type container for later disposal as per the preceding bullet point. The removed polluted soil should either be completely disposed of or cleaned and returned to where it was taken from on site or can be replaced with a cleaner soil. This is to ensure that the pollutants contained int the soil does not infiltrate into the site soils and eventually reach to groundwater.
- Although fuel (diesel) required for exploration equipment will be stored in a tank or tanks mounted on a mobile trailer, drip trays must be readily available on this trailer and monitored to ensure timely cleanup of accidental fuel spills along the tank trailer path/route around the exploration sites. This all aimed at preventing accidental fuel spills or leaks from spreading to the soil and eventually to groundwater.
- Spill control preventive measures should be in place on site to management soil contamination, thus preventing and or minimizing the contamination from reaching groundwater bodies. Some of the soil control preventive measures are:
    - Identification of oil storage and use locations on site and allocate drip trays and polluted soil removal tools suitable for that specific surface (soil or hard rock cover) on the sites.
    - Maintain equipment and fuel storage tanks to ensure that they are in good condition thus preventing leaks and spills.
    - The oil storage and use locations should be visually inspected for container or tank condition and spills.

- Maintain a fully provisioned, easily accessed spill kit. Spill kits should be located throughout the active project sites contain the floor dry absorbent material and absorbent booms, pads, mats. These would be suitable for ground surface areas that are covered mainly by hard rocks.
- All project employees should be made aware of the impacts of soil pollution and advised to follow appropriate fuel delivery and handling procedures.
- Develop and prepare countermeasures to contain, clean up, and mitigate the effects of an oil spill. This includes keeping spill response procedures and a well-stocked cache of supplies easily accessible.
- Ensure employees receive basic Spill Prevention, Control, and Countermeasure (SPCC) Plan training and mentor new workers as they get hired in each phase of the project.

Conclusions

Water abstraction (use): Water abstraction (use): The impact on local groundwater resources (abstraction) will be none because no groundwater will be abstracted from the local aquifers of the project magnitude (small to medium as the required water will be carted into the area. Therefore, the impact on groundwater resources (quantity) from the exploration activities is non-existent, provided that the Proponent strictly uses carted water and not abstract from the local boreholes.

Water pollution: As it is common with every new and existing project, ground surface pollution is anticipated from the project operations and related activities. This potential pollution would be from improper disposal of hazardous products such as hydrocarbons (fuel/oils) and effluent from exploration works on site. The geology of the project area would make the groundwater less vulnerable to pollution from the surface due to the type (igneous and metamorphic rocks) and nature (unfractured/faulted) of rocks would inhibit further spreading pollution of potential pollutants in the water. The avoidance of pollution from reaching the ground surface (into groundwater) and effective implementation of pollution management plans will greatly aid in minimizing groundwater pollution. The impact is therefore considered low (minimal) to slightly moderate and according to the Groundwater Resources Vulnerability to pollution Map, the general site area has a rather low and, in some parts, moderate risk of pollution.

Furthermore, the potential pollution impact is short-term (short lifespan), as it will only be existing during the duration of exploration activities, which means that the impact will be only limited to the duration of the proposed activities.

In conclusion, the proposed project activities will not impact the local groundwater resources therefore the impacts' significance will be none for water quantity (no direct abstraction from local boreholes) and low to slightly medium (for water quality). Therefore, it is vital for the Proponent and their contractors (if any) to effectively implement and monitor the recommended management measures to protect both the biophysical and social water environment. All these would be done with the aim of promoting environmental sustainability while ensuring a smooth and harmonious existence and purpose of the project activities in the hosting biophysical and social environment.

To protect groundwater, it is necessary for different water users in societies to recognize that water resources are finite and vulnerable and find ways to reconcile the demands of human activities with the tolerance of nature. The essential first step to making water use sustainable is awareness and knowledge of human impacts on the environment, specifically on water resources. This will not only be applicable to the project proponents but also members of the public who may have been living in the area prior to developments, such as the proposed exploration.

The Proponent will also be required to ensure that all their activities comply with the legislation governing their project activities with respect to groundwater resources management and protection.

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LIST OF ABBREVIATIONS

°C:	Degree Celsius
µS/cm:	microsiemens per centimetre
ArcGIS:	A geographic information system for working with maps & geographic information
BGR:	Bundesanstalt für Geowissenschaften und Rohstoffe (The Federal Institute for Geosciences and Natural Resources of the Republic of Germany)
CC:	Close Corporation
DEM:	Digital Elevation Model
DGIA:	Desktop Geohydrological (Groundwater) Impact Assessment
DWA:	Department of Water Affairs
EC:	Electrical Conductivity
EEA:	European Environmental Agency
EIA:	Environmental Impact Assessment
EMA:	Environmental Management Act
EMP:	Environmental Management Plan
EPL:	Exclusive Prospecting License
HDPE:	High Density Polyethylene
km:	kilometre
km^2:	square kilometre
m:	Metres
m^3:	Cubic metre
m^3/day:	cubic metre per day
m^3/h:	cubic metre per hour
m^3/year:	cubic metre per year (annum)

mm/a:	millimetre per annum (year)
Mm^3:	Million cubic metres
Mm^3/a:	Million cubic metres per annum (year)
mS/m:	Millisiemens per metre
NamWater:	Namibia Water Corporation Limited (The National Bulk Water Supplier)
OMDEL/Omdel:	Omaruru Delta Aquifer
S-P-R:	Source-Pathway-Receptor
SPCC:	Spill Prevention, Control, and Countermeasure
TDS:	Total Dissolved Solids
TOR:	Terms of Reference

1 INTRODUCTION

Mining is the backbone of the Namibian economy constituting about 9.3% contribution to Gross Domestic Product (GDP). About 52.7% of export-earnings from mining were recorded in the Chamber of Mines' 2013 Annual Report. Other sectors contributing to the GDP include fisheries, agriculture, and tourism (Mweemba, 2014). Minerals extracted in Namibia range from diamonds, uranium, base metals (copper, lead, zinc, etc.), gold, industrial minerals (sand, limestone, and graphite), dimension stones (marble, dolerite) and semi-precious stones/gemstones. Some listed minerals and stones are either mined at a small, medium, or large-scale level, depending on the; ore deposit, specimen size sought after, available resources and geological extent, etc.

The exploration and mining activities of these above-mentioned minerals groups (mainly preceded by exploration activities) usually to certain extents require the use of water to fully operate. Like any other type development (activity), exploration and mining activities usually comes with positive impacts such as income generation, employment creation, contribution to local and regional socio-economic development as well as the country's revenue through taxes and royalties by the project owners (Proponents). However, these activities also associated with some negative (adverse) environmental issues. If these issues (impacts) are not well understood prior to project implementation and enable their timely avoidance or significance reduction, they can potentially harm both the physical and social environment or its components during the project lifecycle. One of the vital environmental physical components that can be potentially impacted by the exploration activities is water resources, particularly groundwater.

Groundwater is one of the most valuable yet vulnerable natural resources for people, animals, and the general environment owing to sudden adverse changes in the water systems. Therefore, affecting water resources systems and overall natural environment functionality. It is, therefore, very crucial to understand the impacts of proposed (new) projects on groundwater, in terms of over-utilization (over-abstraction) and pollution (quality). Groundwater over-abstraction does not only result in aquifer depletion and water-quality degradation, but also impacts the ecological integrity of streams and wetlands, resulting in significant losses of habitat and biodiversity. This impact is felt more in semi-arid and arid areas with high water demand and low rainfall (limited groundwater recharge) compared to humid areas. In other words, although water scarcity often happens in areas with low rainfall, human activities aggravate the problem particularly in areas with high population density, tourist inflow, intensive agriculture and other water demanding industries.

Over abstraction of groundwater leads to water scarcity, whereby there is insufficient water resources to satisfy long-term average requirements. According to the European Environmental Agency (EEA) (2018), water scarcity refers to long-term water imbalances, combining low water availability with a level of water demand exceeding the supply capacity of the natural system. Water scarcity is driven primarily by two factors:

- Climate, which controls the availability of renewable freshwater resources and seasonality in water supply, and
- Water demand, which is largely driven by population and related economic activities

With every new project planned for in the society (natural and social environment), it is vital that all possible impacts on water resources from such developments' activities are considered, how to prevent them and or minimize their significance (if avoidance is impossible) and come up with practical mitigation measures. All this is done to ensure that the projects and development activities run in an environmentally and socially manner to ensure sustainability, while maximizing the positive impacts (benefits) of the projects.

This document aims to confirm, assess potential impacts on groundwater resources associated with the proposed exploration activities in the Erongo Region, inland of the west coastal side of Namibia, and provide mitigation measures to avoid and or minimize the significance of these impacts.

With that in consideration and commitment to continue operating to generate income, positively impact the lives of Namibian citizens (through employment) and economic development to the Erongo Region and Namibian nation, as one of the dimension stone exploration companies in Namibia, Best Cheer Investments Namibia intends to continue with their line of operations, which is exploration. They intend on doing this by exploring on prospective target areas of an exclusive prospecting license (EPL).

For Namibia, water resources are protected under Water Act (1956) and the new Water Resources Management Act (2013). Water resources protection and management is also listed under the Environmental Management Act No. 7 of 2007 and its 2012 Environmental Impact Assessment (EIA) Regulations as one of the activities that may not be undertaken without an environmental clearance certificate (ECC). Most importantly for this project, the EMA also made provision for ECC abstraction and use of groundwater for commercial purposes (only for mining activities to be specific, since it is when project owners/proponents start to make profit from selling the mined commodities). The EMA requirements would include a condition for the proponents to apply for and obtain groundwater abstraction and use permit from the Department of Water Affairs. However, with that said, exploration activities would not require such a permit.

To ensure that all the significant environmental components are considered and to satisfy the requirements by both the Proponent and public (public consultation requests), as part of the main EIA study, Omavi Geotechnical & Geo-Environmental Consultants(the project Environmental Consultants) subcontracted Ms. Fredrika Shagama (an independent Hydrogeologist) to undertake a desktop groundwater (hydrogeological) assessment for the proposed project activities.

It is for this reason, that this desktop groundwater impact assessment report was compiled. The aim of the report was to determine the possibility of groundwater being impacted by the proposed exploration activities on the EPL, assess the potential impacts, and provide the necessary management measures to reduce the significance of these impacts.

1.1 Brief Project Background and Location

The Namibian water resources are protected by the old Water Act No. 54 of 1956 and the new unpromulgated Water Resources Management Act No. 11 of 2013, that require that a water abstraction and use permit should be obtained for every commercial water use. The abstraction and use of water resources (groundwater) is also listed under the Environmental Management Act No. 7 of 2007 and its 2012 Environmental Impact Assessment (EIA) Regulations as one of the activities that may not be undertaken without an environmental clearance certificate.

It is for these legal reasons that Best Cheer Investments Namibia (Pty) Ltd (hereinafter referred to as Best Cheer Investments Namibia or the *Proponent*) appointed Omavi Geotechnical & Geo-Environmental Consultants CC (hereinafter referred to as *Omavi Consultants*) to undertake the required environmental assessment for their proposed exploration activities on Exclusive Prospecting License (EPL) 5161 located about 15 km northeast of the Arandis Town in the Erongo Region (the *project*) - **Figure 1**. Potential commodities on EPL 5161 include base and rare metals, dimension stone, nuclear fuel mineral and precious metals. However, for the purpose of this project, only dimension stone has been applied for and the reason for this study. The EPL covers a surface area of 5 058 hectares (ha). Best Cheer Investments Namibia intends to undertake exploration activities on the EPL. **It should be noted that this document only covers the exploration phase activities.**

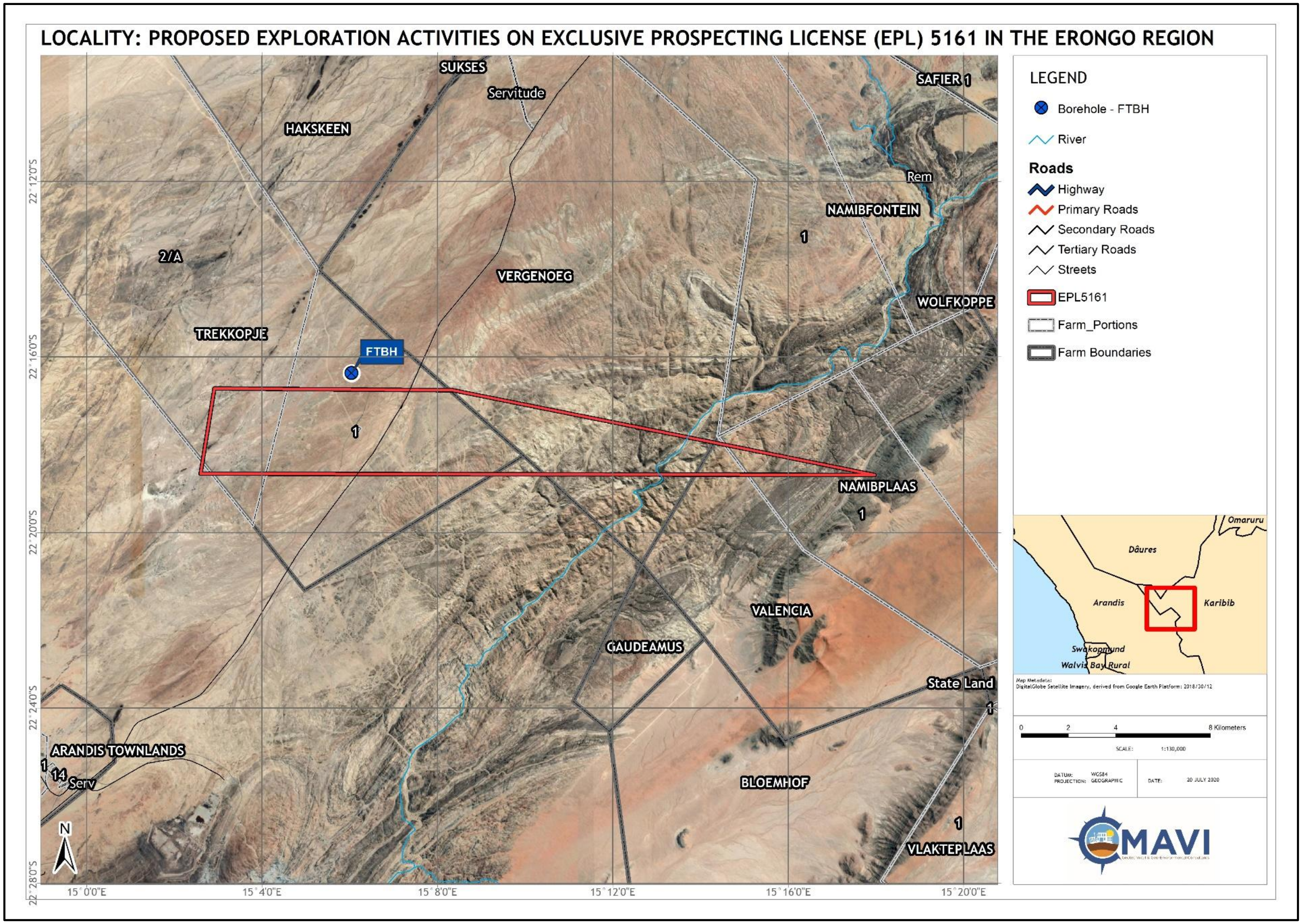


Figure 1:Location of the EPL 5161 (project site) near Arandis in the Erongo Region

2 TERMS OF REFERENCE, SCOPE OF WORKS AND LIMITATIONS

2.1 Terms of Reference for the Study

There was no formal Terms of Reference (TOR) provided by Omavi Consultants. However, this document has been prepared as guided by their requirement for the water resources component as part the main project Environmental Impact Assessment (EIA). The water resources impact assessment covered in this report primarily deals with the potential impacts of the proposed exploration activities on groundwater resources on site and in the immediate areas.

2.2 Scope of Works

The scope of work for this study is limited to the water resource impact assessment with a cursory look at the project impacts on groundwater in terms of quantity (abstraction) and quality (pollution). The scope of works for this study is presented below:

- Baseline assessment (desktop study) of existing site information as provided by Omavi Consultants and general literature on the broader area in relation to the proposed project site and overall project activities.
- A review and brief presentation of legislation that governs water resources management and protection in Namibia.
- A description of the physical conditions; climatic, pedological (soil), geological, hydrological (surface) and hydrogeological (groundwater) conditions of the project site area.
- The proposed (future) water abstraction for the project activities.
- Determination/estimation of the groundwater rapid (desktop) reserve of the project area and sustainable (abstractable) water volume per day (and year); and
- Identification of the potential impacts from the proposed project activities on groundwater resources, their descriptions, assessment, and recommendations on mitigating these impacts.

2.3 Limitations of the Study

The following assumptions apply to this assessment:

- This report has been compiled on a desktop level i.e. no detailed fieldwork/site visit was conducted by the Author for this assessment. The project specific information used in this document is as provided by Omavi Consultants from the Proponent.
- The Author assumes that all the project information and data provided by Omavi Consultants and the Proponent is correct and accurate, and that all necessary information has been disclosed.
- It is also assumed that the relevant information obtained from different literature consulted is accurate; and

- The report has been compiled on an assumption that there will be no significant changes to the proposed activity or the affected water environment between the time of compiling this report and implementation of the proposed project activities that could substantially influence findings of this document. It is also assumed that there will be no significant changes to the project activities that could substantially influence the mitigation measures given and recommendations made for the management and protection of groundwater resources.

The methodology employed for this study (assessment) is presented under the following chapter.

3 APPROACH AND METHODOLOGY

To ensure that the requirements of the study addresses the main issues, the following methods and tasks have been employed to aid in undertaking a concise assessment and to make informed decisions.

3.1 Desktop (Baseline) Study

For this study, an analysis of existing project information as presented by Omavi Consultants and Proponent and reviewing of literature and legislation relevant to the study (baseline assessment) were undertaken. This review entails reports containing information on the area geology, soil, climate, and hydrology. Other existing reports of similar or related studies conducted in the area were also reviewed. This also entailed the review of relevant books in the field of hydrogeology that significantly contribute to the study.

3.2 Impact Assessment Methodology

The potential impacts of the project activities on the groundwater resources has been described and presented as per criteria presented under section 3.2.1 and section 3.2.2, respectively and in detail under Chapter 8 (impacts' description and assessment). The mitigation (management) measures to avoid or minimize these potential impacts are provided under Chapter 9.

The methodology used to assess and determine the significance of the potential project impacts on the water resources is as explained below.

3.2.1 General Concept of Impact (Risk) Assessment

Generally, an environmental risk occurs when there is a hazard (e.g. process, activity, or substance) that can result in a harmful impact on the surrounding environment. The part of the environment which is, or could be, affected is known as a receptor. Receptors include humans, flora and fauna, the built environment and water resources (controlled waters).

According to SRK (2006), the presence of a hazard alone does not constitute a risk; a risk is only present if there is a means by which the hazard can impact on sensitive receptor(s). The connection between the hazard and receptor is known as a pathway, and all three elements together.

The risk/impact assessment is driven by three factors and these are:

- **Source:** The cause or source of the contamination.
- **Pathway**: The route taken by the source to reach a given receptor; and
- **Receptor:** A person, animal, plant, eco-system, property, or a controlled water source. If contamination is to cause harm or impact, it must reach a receptor.

A pollutant linkage occurs when a source, pathway and receptor exist together (Booth, 2011). The objective with the mitigation measures is to firstly avoid the risk and if the risk cannot be avoided, mitigation measures to minimize the impact are then recommended. Once the mitigation measures have been applied, the identified risk will be of low significance, provided there is sufficient monitoring of measures' implementation.

3.2.2 Impact Assessment Criteria

The methodology employed for this assessment was adopted from typical environmental assessment reports based on research and analysis of other consultants' reports on the suitable project assessment methodology.

The proposed exploration activities will likely to some scale/extent (spatial scale), magnitude (severity) and duration (temporal scale) have impacts on certain biophysical and social components. The potential impacts were assessed as per methodology presented in **Table 1**.

To enable a scientific approach to the determination of the environmental significance, a numerical value is linked to each rating scale. This methodology ensures uniformity and that potential impacts can be addressed in a standard manner so that a wide range of impacts are comparable.

It is assumed that an assessment of the significance of a potential impact is a good indicator of the risk associated with such an impact. The following process will be applied to each potential impact:

- Provision of a brief explanation of the impact.
- Assessment of the pre-mitigation significance of the impact; and
- Description of recommended mitigation measures.

The recommended mitigation measures prescribed for each of the potential impacts contribute towards the attainment of environmentally sustainable operational conditions of the project for various features of the biophysical and social environment. The impact assessment criteria used is presented in **Table 1**.

Table 1: Impact assessment criteria

Nature	Description	Rating
Extent (Spatial scale)	An indication of the physical and spatial scale of the impact.	**Low (1):** Impact is localized within the site boundary: Site only. **Low/Medium (2):** Impact is beyond the site boundary: Local. **Medium (3):** Impacts felt within adjacent

Nature	Description	Rating
		biophysical and social environments: Regional. **Medium/High (4):** Impact widespread far beyond site boundary: Regional **High (5):** Impact extend National or over international boundaries.
Duration	The timeframe, over which the impact is expected to occur, measured in relation to the lifetime of the project.	**Low (1):** Immediate mitigating measures, immediate progress **Low/Medium (2):** Impact is quickly reversible, short term impacts (0-5 years) **Medium (3):** Reversible over time; medium term (5-15 years). **Medium/High (4):** Impact is long-term. **High (5):** Long term; beyond closure; permanent; irreplaceable or irretrievable commitment of resources
Intensity, Magnitude / Severity (Qualitative criteria)	The degree or magnitude to which the impact alters the functioning of an element of the environment. The magnitude of alteration can either be positive or negative	**Medium/low (4):** Low deterioration, slight noticeable alteration in habitat and biodiversity. Little loss in species numbers. **Low (2):** Minor deterioration, nuisance or irritation, minor change in species / habitat / diversity or resource, no or very little quality deterioration.
Probability of occurrence	Probability describes the likelihood of the impacts occurring. This determination is based on previous experience with similar projects and/or based on professional judgment	**Low (1):** Improbable; low likelihood; seldom. No known risk or vulnerability to natural or induced hazards. **Medium/low (2):** Likely to occur from time to time. Low risk or vulnerability to natural or induced hazards. **Medium (3):** Possible, distinct possibility, frequent. Low to medium risk or vulnerability to natural or induced hazards. **Medium/High (4):** Probable if mitigating measures are not implemented. Medium risk of vulnerability to natural or induced hazards.

Nature	Description	Rating
		High (5): Definite (regardless of preventative measures), highly likely, continuous. High risk or vulnerability to natural or induced hazards.

3.2.3 Impact Significance

This is determined through a synthesis of the above impact characteristics (in **Table 1** above). The significance of the impact "without mitigation" is the main determinant of the nature and degree of mitigation required. As stated in the introduction to this chapter, for this assessment, the significance of the impact without prescribed mitigation actions was measured.

Once the above factors (**Table 1**) have been ranked for each potential impact, the impact significance of each is assessed using the following formula:

SP = (magnitude + duration + scale) x probability

The maximum value per potential impact is 100 significance points (SP). Potential impacts were rated as high, moderate, or low significance, based on the following significance rating scale (**Table 2).**

Table 2: Impact significance rating scale

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

For an impact with a significance rating of high, mitigation measures are recommended to reduce the impact to a low or medium significance rating, provided that the impact with a medium significance rating can be sufficiently controlled with the recommended mitigation measures. To maintain a low or medium significance rating, monitoring is recommended for a period to enable the confirmation of the significance of the impact as low or medium and under control.

The assessment of the project impacts is done for both pre-mitigation (before implementing any mitigation) and post-mitigation (after mitigations are implemented).

3.3 Reporting

All the information obtained from the project Proponent, site knowledge (by Omavi Consultants) and literature review have been analysed and consolidated into this document. The information includes physical settings/conditions of the area, relevant maps, water resources, impact assessment, and recommendations on water resources management and protection. The recommendations made herein will be incorporated into the project Environmental Management Plan (EMP) by Omavi Consultants as the Environmental Assessment Practitioner.

The following chapter presents the national and international legal requirements that are applicable and relevant to this assessment and groundwater resources

4 LEGAL FRAMEWORK FOR WATER RESOURCES MANAGEMENT AND PROTECTION

The project's primary purpose entails the exploration of dimension stone and this will at some extent require the use of water. The exploration activities, depending on their operational scales and type can potentially have impacts on the water resources, specifically groundwater (in terms of quantity and quality). It is therefore necessary to consider the national legislations and legal requirements governing the water management and protection.

4.1 Applicable National Legal Framework

The Namibian legislations that govern the use, management and protection of water resources and related activities are as follows:

- **Water Act No. 54 of 1956**: To consolidate and amend the laws relating to the control, conservation and use of water for domestic, agricultural, urban and industrial purposes; to make provision for the control, in certain respects, of the use of sea water for certain purposes; for the control of certain activities on or in water in certain areas; for the control of activities which may alter the natural occurrence of certain types of atmospheric precipitation; for the control, in certain respects, of the establishment or the extension of townships in certain areas; and for incidental matters.
- **Water Resources Management Act No. 11 of 2013:** This Act (Government Gazette 5367) has been passed by Parliament, but it has not yet been brought into force. The Regulations have been passed in December 2016 but have not yet been promulgated. Therefore, the Regulations of the 1956 Water Act still apply. The objectives of this Act are to ensure that the water resources of Namibia are managed, developed, used, conserved, and protected in a manner consistent with, or conducive to, the fundamental principles set out in relevant Sections.

- **Environmental Management Act No. 7 of 2007 and its 2012 Environmental Impact Assessment (EIA) Regulations:** The Act aims at promoting sustainable management of the environment and use of natural resources. The Environmental Management Act (EMA) is broad; it regulates land use development through environmental clearance certification and/or Environmental Impact Assessments. The Act provides for the clearance certification for:
    - ***''Regulation 3.1 The construction of facilities for any process or activities which requires a license, right or other forms of authorization, and the renewal of a license, right or other form of authorization, in terms of the Minerals (Prospecting and Mining Acts), 1992***
    - ***Regulation 8.1 The abstraction of ground or surface water for industrial or commercial purposes."***
- **Soil Conservation Act No.76 of 1969:** The Act makes provision for the prevention and control of soil erosion and the protection, improvement and conservation of soil, vegetation and water supply sources and resources, through directives declared by the Minister.
- **The Water Policy:** National Water Policy White Paper, August 2000 (this laid the basis for the new Water Resources Management Act).

The relevant baseline environment of the project site and surrounding broader area interest is presented under the following chapter.

5 DESCRIPTION OF THE (RELEVANT) RECEIVING ENVIRONMENT

The baseline (pre-project site conditions) information of a project area is crucial to one's understand as it aids in undertaking a concise assessment and make informed conclusions on the proposed project's impacts on environmental components, such as water resources. The baseline information (conditions) of the site area and broader area that are relevant to this assessment are briefly described below.

5.1 Climate and Topography

According to African Planning Forum (2019), Arandis generally experiences all year healthy and bearable climatic conditions where warm days are followed by cool nights. Thus, Arandis can be considered to have a desert climate.

The spatial potential evaporation distribution in Namibia map is presented in **Figure 2** with the project area being in the range of 3 200 to 3 400 mm/a. The location of the Arandis area being the nearest town to the EPL site is estimated by the red arrow (between Swakopmund and Usakos) on the western coastal part of Namibia.

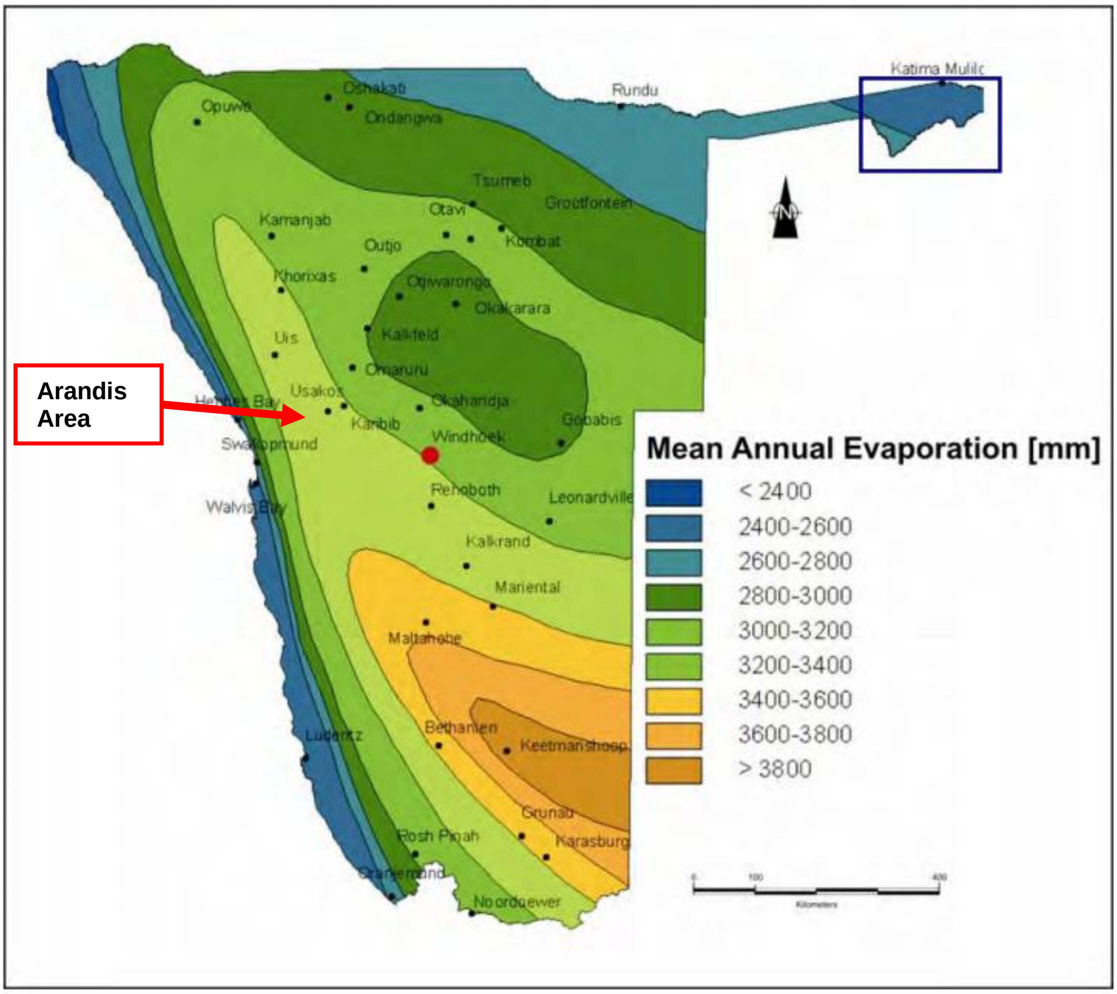


Figure 12: Spatial Distribution of Potential Evaporation in Namibia
(adopted from DWA, unpublished data)

Figure 2: The spatial distribution of potential evaporation in Namibia (after BGR, 2005)

The only rains fall during the summer months and on average most of this rainfall is experienced from February to April (African Planning Forum, 2019). In the past 10 years, the highest rainfall recorded for Arandis was 51 mm (in February 2011) – **Figure 3**. African Planning Forum (2019) further states that occasional thunderstorms however do occur turning the small river courses into fast flowing rivulets and flash flood conditions do occur. The average rainfall for the region over the long term is less than 100 mm per year but due to the erratic distribution, much of the area receives less than 50 mm per year.

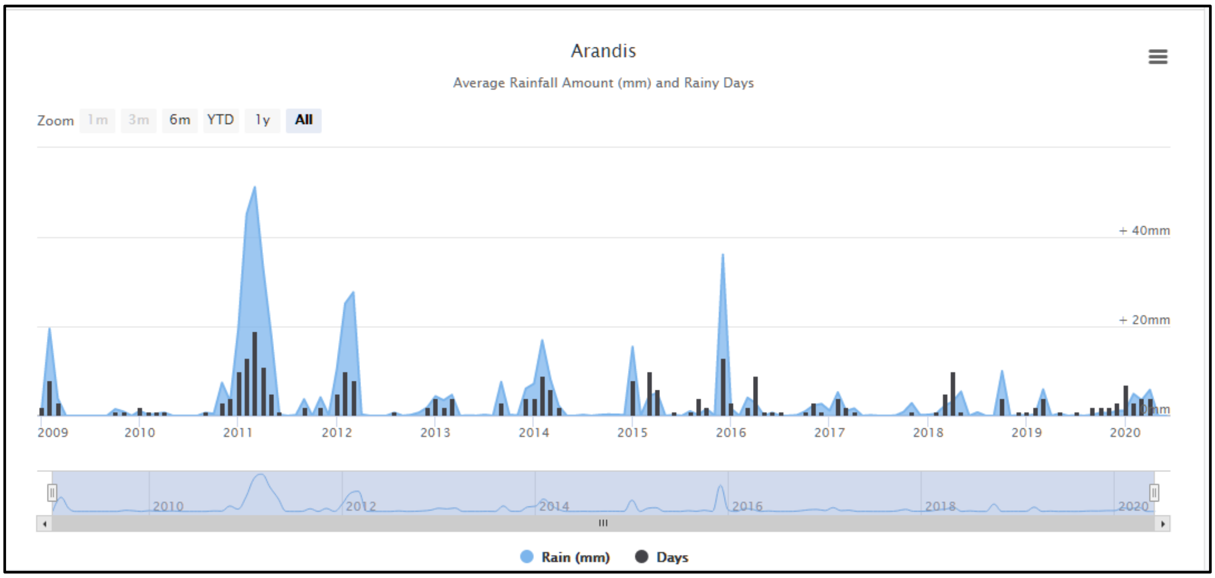


Figure 3:The rainfall patterns for the Arandis area (source: World Weather Online, 2020)

The maximum temperatures recorded for the site area for the period of 2010 and 2020 range between 17°C and 27°C whereas the minimum temperatures range between 13°C and 21°C. The average temperatures between 13 and 19°C. These temperature components are shown in **Figure 4** below.

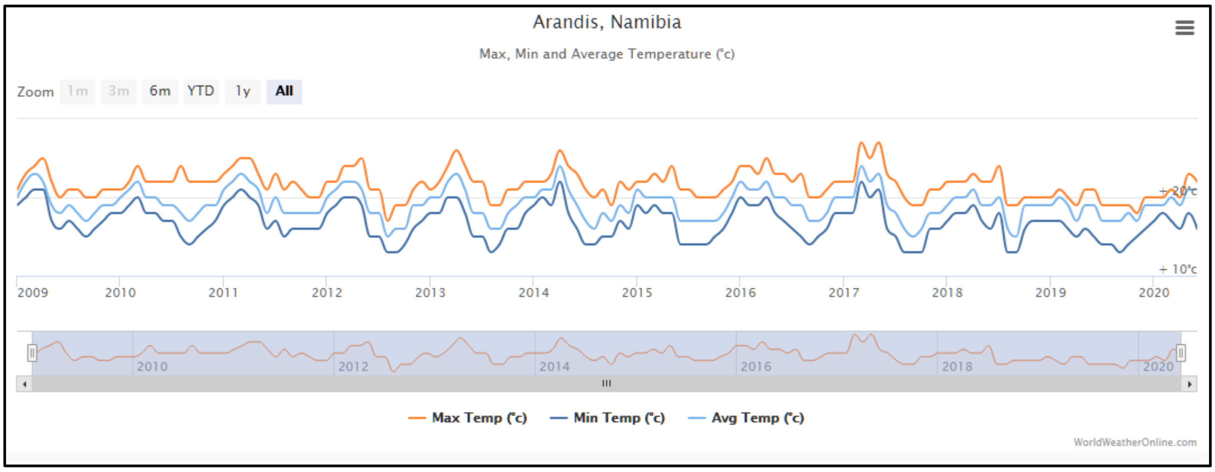


Figure 4:The maximum, minimum and average temperature Arandis area (source: World Weather Online, 2020)

With regards to topography, the town of Arandis is located some 581 metres above mean sea level. The area is characterized by undulating hills and sandy valley areas (Africa Planning Forum, 2019). In the Erongo Region, the land rises steadily from sea level to about 1,000 m across the breadth of the Namib. The Namib land surface is mostly flat to undulating gravel plains, punctuated with occasional ridges and isolated 'inselberg' hills and mountains (Southern African Institute for Environmental Assessment (SAIEA), 2011). Aurecon Environment and SLR Environmental Consulting (2014) further state that broad geomorphological characteristics include a shore of mixed sand and rock, with gravelly coastal plains in the study area, with the Arandis Mountain (just over 600 m high) further to the east and a narrow dune belt further to the south.

5.2 Soil and Geology

According to GCS Water & Environmental Consultants (2017), the soils of Namib Desert are knowns as "syrosems" and calcareous soils. The syrosem soils were formed when solid rock is exposed, mainly broken down by mechanical weathering. Rock fragments and exfoliation chips gather around the outcrops, where they undergo further processes of weathering. The calcareous (from limestone) soils were formed during a pluvial period when a minimum of groundwater was available. The subsoil rises to the surface through capillary action and deposits the dissolved $CaCO_3$ on evaporation, forming the deep soils. The texture of the Namib Desert soil is classified as coarse to moderately coarse. These soils are prone to collapse when disturbed

The geology of the central region is dominated by the Damara Sequence. This sequence underlies most of central and northern Namibia. The basal arenitic succession of the Nosib Group was laid down between 850 and 700 million years (Ma) ago. There is a large gap in the geological history of the central area after the Damara orogenesis. Sediments of the Karoo Sequence were deposited and largely eroded afterwards, except for some remnants preserved under volcanic rocks. In the early Cretaceous, the continental breaks up of South America and Africa caused widespread volcanic activity. From 180 to 120 Ma ago, basaltic lava erupted from deep-seated fissures and covered large parts of Namibia. Erosion has removed most of these sheet basalts, but their feeder channels are still present in the form of dolerite dykes (**dolerite is a coarse-grained basalt**). The north-north east striking dykes are found throughout the Namib Desert (Christelis and Struckmeier, 2011). A general geological setting of the project area (enclosed by a light green rectangle) is shown in **Figure 5** below.

Period/ Era	Age Ma	Sequence	Group	Formation	Lithology	Hydrogeological Control
Quaternary	70 and younger		Kalahari & Namib		Alluvium Sand Clay Gravel Calcrete Scree Gypcrete	Unconsolidated deposits of sand and gravel in palaeochannels allow infiltration of surface run-off in riverbed (Unconfined aquifer). Clay rich sand acts as confining layer (delayed yield effect). Gravel layers act as main aquifer.
Cretaceous	137-125	Damaraland igneous suites; mainly granite (Messum, Brandberg, Erongo)				Related tectonic action resulted in scouring of several palaeochannels in underlying bedrock
	132		Etendeka	Awahab	Basalt & dolerite dykes	Dolerite dykes react as semi-pervious and /or screening barriers
Permian to Triassic	300-180	Karoo	Ecca	Huab Gai-as Verbrande Berg	Mudstone siltstone sandstone shale	Eroded or scoured away during tectonic activities during intrusion of Damara igneous suites
Namibian/ Cambrian to Ordovician	550-450	Salem-type granite & red granite intrusions associated with tectonic activity (Syn- and post-tectonic)				Bedrock of the aquifer (impermeable layer). Water bearing capabilities are only limited to fractured or decomposed portions
Namibian/ Neoproterozoic	770-600	Damara Orogen	Swakop	Kuiseb	Mica schist	
				Arandis Karibib	Marble	
	740-600		Zerrissene	Amis	Phyllite	
	850-750		Nosib	Naauwpoort	Quartzite	

Figure 5:Geological features of the project area as presented with regards to the Omdel Aquifer (edited after Matengu et al, 2019)

The geology of the area is also characterized by relatively flat light-brown sand, rocky and gravel plains of the Namib Desert with outcrops of granite and quartzite (GCS Water & Environmental Consultants, 2017). Although windblown sand is found along the foot of the **dolerite ridges** the topsoil found within the Arandis area generally comprise of gravel plains comprising of surface quartz gravels (Africa Planning Forum, 2019). Site observations indicated the presence of granite and calc-silicate outcrops.

The general geology map of the project site and surrounding areas is shown in **Figure 6** with the approximate project area enclosed by the green ellipse.

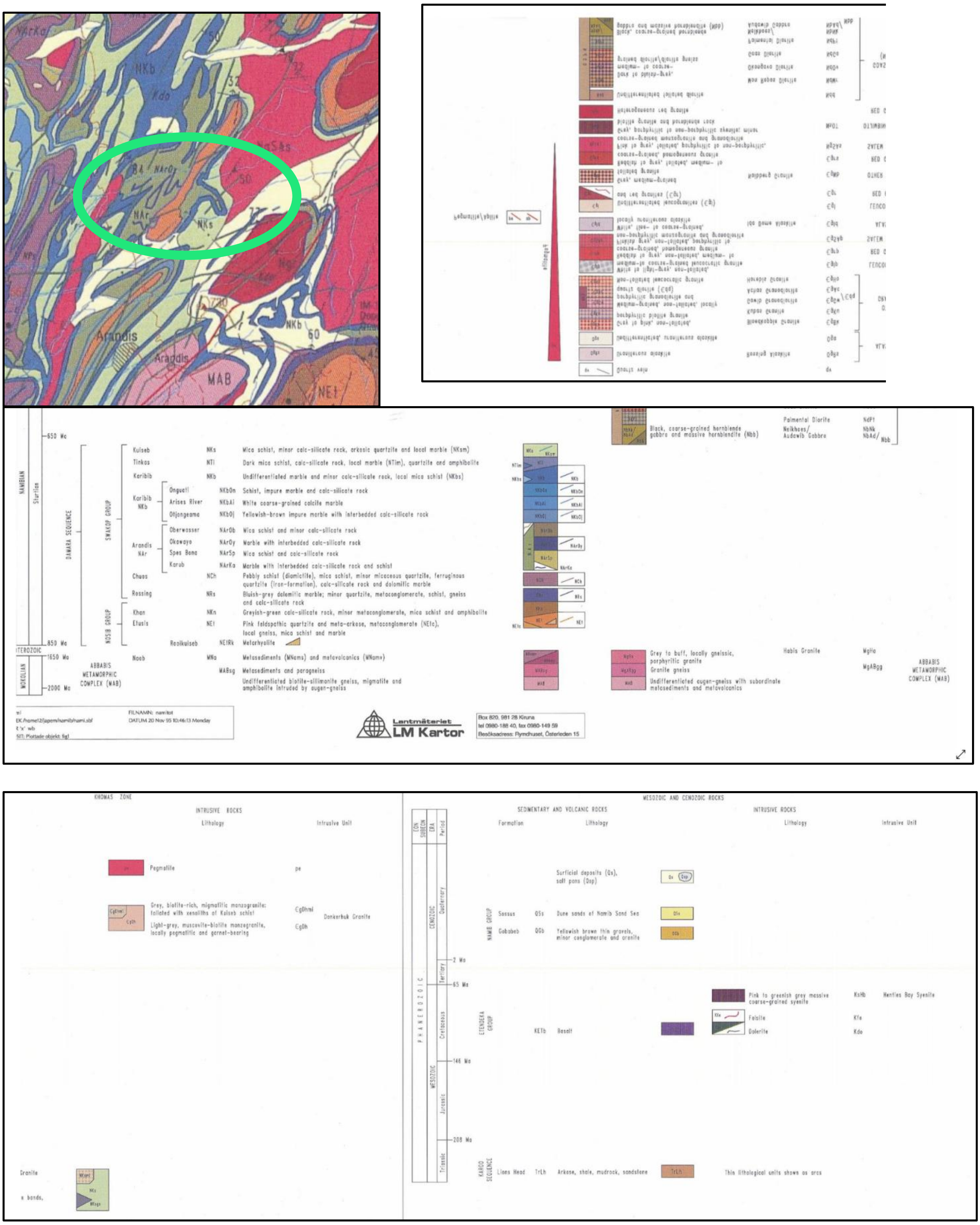


Figure 6:Approximate geological section (map) and Legends of the project site area extracted from a 1:250 000 geological sheet

5.3 Hydrology and Catchments

The site area does not have significant natural surface bodies such as rivers. According to Africa Planning Forum (2019), the only nearby surface water body is the Khan River, a prominent ephemeral river located south of the Arandis Town. The town therefore falls within the Kahn River catchment area of which in turn is part of the greater Swakop River catchment area. Further north of the town the catchment area of the Omaruru River is found. All these rivers are ephemeral and are dry for most parts of the year.

Given the proximity of the project site to the Town of Arandis, it is assumed that the site also falls within the same (Khan River) catchment. According to Strohbach (2008), the Khan River has a surface area of 8 399 274 km^2. This River is located on the eastern side of the EPL, following a south-eastern southwestern trend.

5.4 Hydrogeology

The project site is within the groundwater basin of the Central Namib-Windhoek Area, which according to Christelis and Struckmeier (2011) extends from Windhoek in the east to the Atlantic Ocean in the west. Several towns are situated in the catchment of the Swakop and Khan rivers: Okahandja, Otjimbingwe, Karibib, Usakos and Arandis as well as the Rössing uranium mine.

The fact that most towns in the western Central Region are situated on or near rivers reflects groundwater availability in the area. Sufficient water for larger settlements can only be obtained by surface water storage in dams or from alluvial aquifers, while the potential of bedrock aquifers is very limited. This is partly due to the low rainfall and lack of recharge, and partly to the generally unfavourable aquifer properties of Damara Sequence rocks (Christelis and Struckmeier, 2011). Groundwater reserves in the vicinity of the study area are limited to the Kuiseb, Swakop, and Omaruru alluvial bed aquifers of the Erongo groundwater basin, which supply Henties Bay, Swakopmund and Walvis Bay as well as Arandis, and historically Rössing Uranium and Langer Heinrich Mines (Aurecon Environment and SLR Environmental Consulting, 2014).

Christelis and Struckmeier (2011) further states that moderate yields are also encountered in the marble and schist aquifers around Karibib and the calcrete aquifer in the Kranzberg area at Usakos. But while the marbles supply the much larger town of Otjiwarongo further north, the recharge at Karibib is insufficient to maintain the required yields, and the water supply to the town and Navachab gold mine is augmented by the Swakoppoort Dam. Borehole yields decrease to very low and limited in the Namib.

The Hydrogeological map of Namibia with groundwater potential of rock units is shown in **Figure 7** According to this map, the project site area (as shown by the green arrow) is largely found in generally low, locally moderate groundwater potential and in some further areas, very low and limited potential.

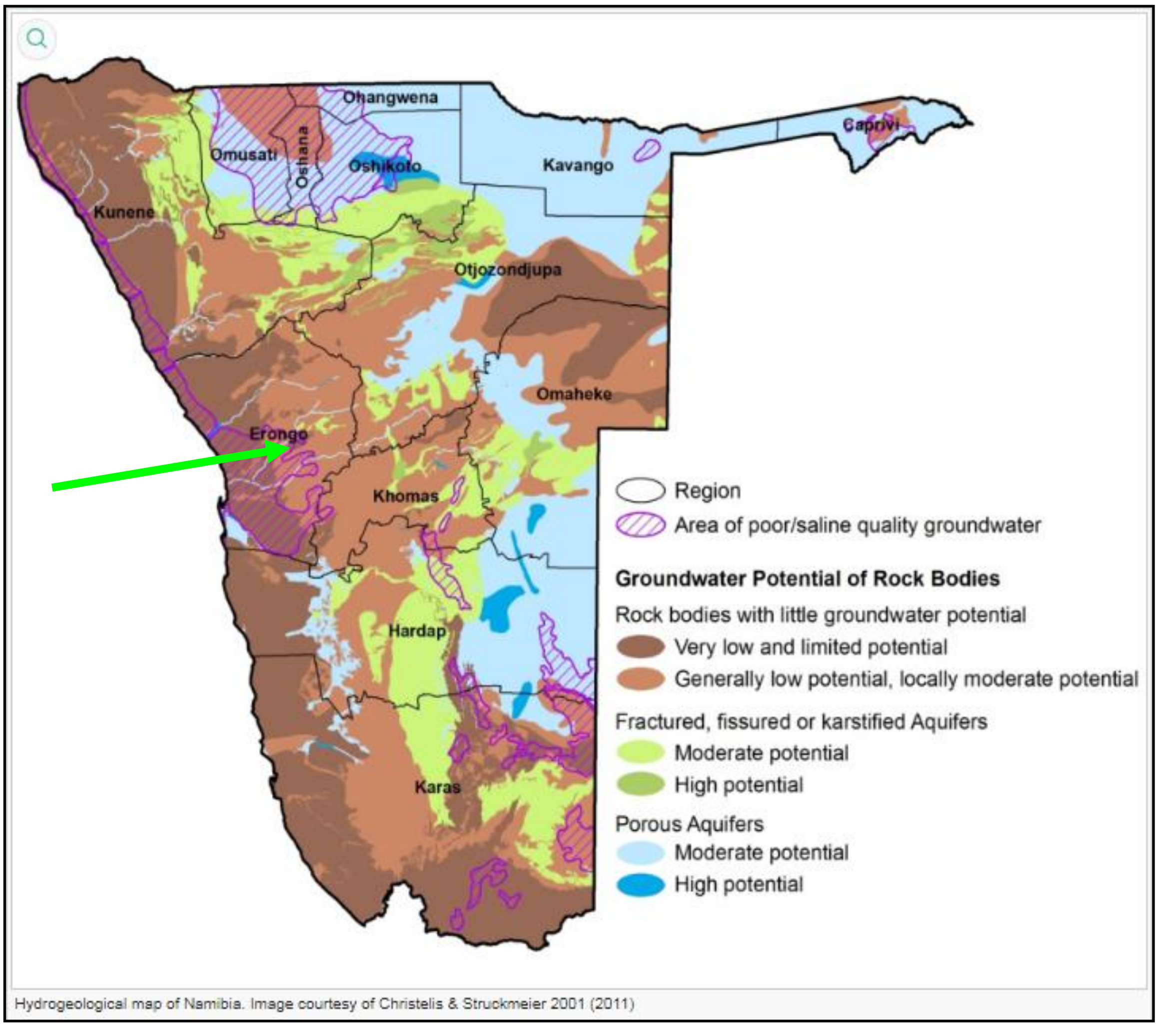


Figure 7:Hydrogeological map of Namibia with rock bodies groundwater potential with the approximate location of project site indicated by the light green arrow on the map

5.4.1 Groundwater Recharge

The effective groundwater recharge from rainfall is the portion of rainfall that reaches the groundwater table. The remainder of the rainfall is lost to surface water runoff, evapo-transpiration, and soil moisture. The effective rainfall-recharge is dependent on the rainfall intensity, soil and vegetation characteristics, catchment geology, surface water ponding and the available storage. As a general principle, it can be assumed that an increase in water available in a portion of the catchment (from rain or ponding of surface water) would increase the recharge in the area. Thin soil cover further promotes recharge.

Usually, groundwater recharge of a site is calculated from a conservative annual recharge derived from annual rainfall. A recharge value for the two sub-catchments was calculated from recharge zones given by Winker (2010) and these are shown in **Figure 8** below with the Arandis and the EPL site area indicated as ''***PS***''.

Recharge rates of the catchments which reported by several investigations varied from 0.3 to 10 % of annual rainfall (Winker, 2010). Given low rainfall received in Namibia over the past years, and climatic conditions of the project area, **normal or worst-case scenario rainfall and conservative annual**

rainfall values are always used to estimate groundwater reserve of the area to ensure that calculations and resulting values are not over-exaggerated and distorted from real site conditions.

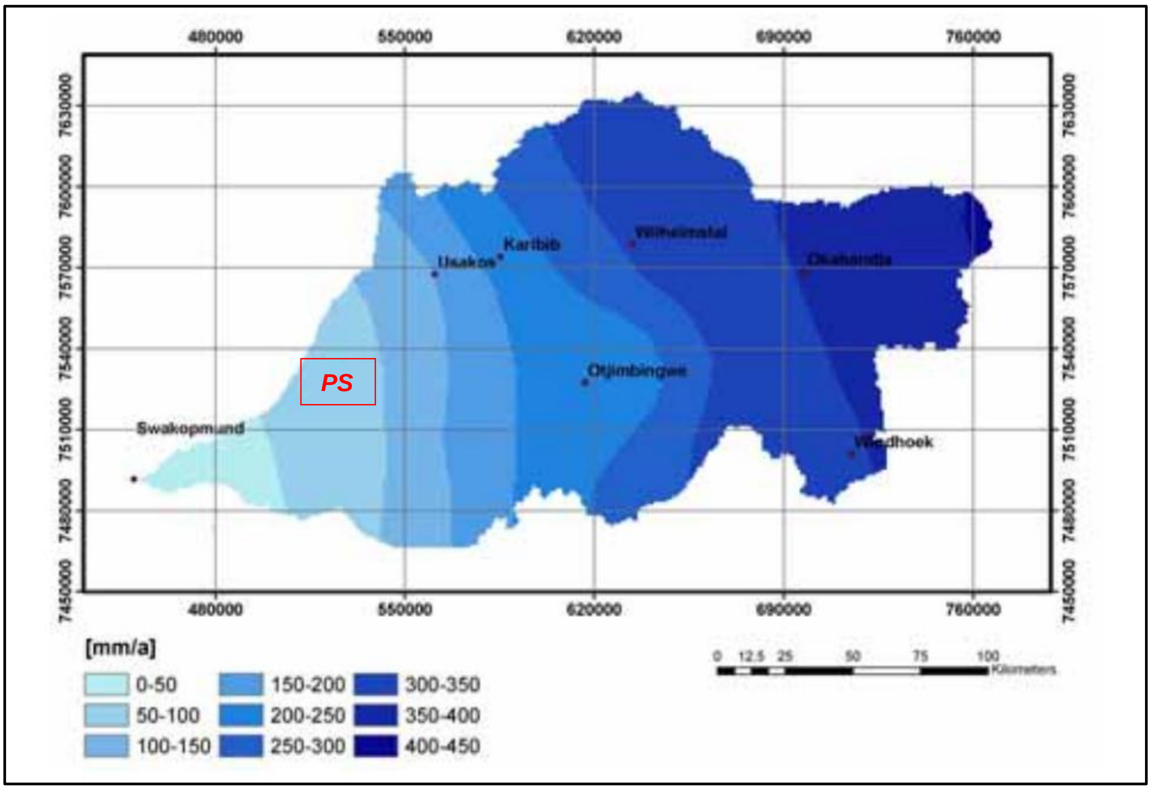


Figure 8:Recharge zones derived from annual rainfall map (DEA, 2002), after Winker (2010)

5.4.2 Baseline Groundwater (Borehole) Yields and Levels

Moderate yields are also encountered in the marble and schist aquifers around Karibib and the calcrete aquifer in the Kranzberg area at Usakos. But while the marbles supply the much larger town of Otjiwarongo further north, the recharge at Karibib is insufficient to maintain the required yields, and the water supply to thetown and Navachab gold mine is augmented by the Swakoppoort Dam. Other bedrock aquifers in the eastern part of the Namib, e.g. in the former Damaraland, are barely able to supply enough water for stock watering. Many dry boreholes were drilled in this area. The yield potential is generally low, but locally moderate. Yields decrease to very low and limited in the Namib (Christelis and Struckmeier, 2011).

The groundwater map (in **Figure 7**) presents a color scheme that subdivides the rock bodies into aquifer (blue, green) and non-aquifers (brown) and further into fractured (green) or porous (blue) ones. Dark blue and dark green illustrate aquifers with high potential and yields generally above 15 m^3/h, while the light colors describe aquifers with moderate potential and yields between 3 and 15 m^3/h (Winker, 2010). With that said, it can be safely concluded that the light and dark brown colors in the same map represent areas of very low, limited and generally water potential with yield less than 3 m^3/h. **This is the scenario with the project area (Arandis Town and the EPL site area). However, moderate potential and yield areas could be encountered on certain local aquifers (small light green patches around the project area in the map). The probability of encountering such aquifers would be depended on correct siting of boreholes in the area targeting these specific moderate aquifer bodies.**

During the site visit conducted on 18 July 2020, two boreholes were observed within the site area, near Farm Trekopje. The borehole near the Farm was dug by hand and has salty water which is only used for livestock (sheep) watering and has a water level of 11 m below ground. This borehole location is shown in the locality map in Figure 1 and sub-catchment map under Figure 12 under Chapter 7. The borehole has been names as Farm Trekopje borehole (FTBH) and its coordinates are presented below.

FTBH GPS Coordinates: 22°16'22.19"S 15° 6'2.59"E

The second borehole that is located about 20 m southeast from the Farm borehole is Government drilled and owned (as part of the Rural Water Supply Scheme) and the water level was recorded at 10.3 m below ground. This borehole water is also saline.

5.4.3 Groundwater Quality

According Christelis and Struckmeier (2011), groundwater in fractured aquifers between the coast and 20-150 km inland is mostly saline. Fractured aquifers with inadequate yields are used at the Spitzkoppe (94) and Tubussis (101) water supply schemes. The Spitzkoppe is a popular tourist attraction in the Erongo Region. The mountain consists of granite intruded into meta-sediments of the Swakop Group. A settlement established at the foot of the mountain depends mainly on tourism and some small stock farming. The water scheme's boreholes are sited on fractures intersecting the small Spitzkoppe River. **Their yields are low, recharge is erratic, and its absence leads to poor water quality of Group C-D**. A treatment plant to improve water for domestic consumption has been built.

A local groundwater quality assessment was conducted by BGR for the Khan and Swakop River Catchments in 2010 – **Figure 9**.

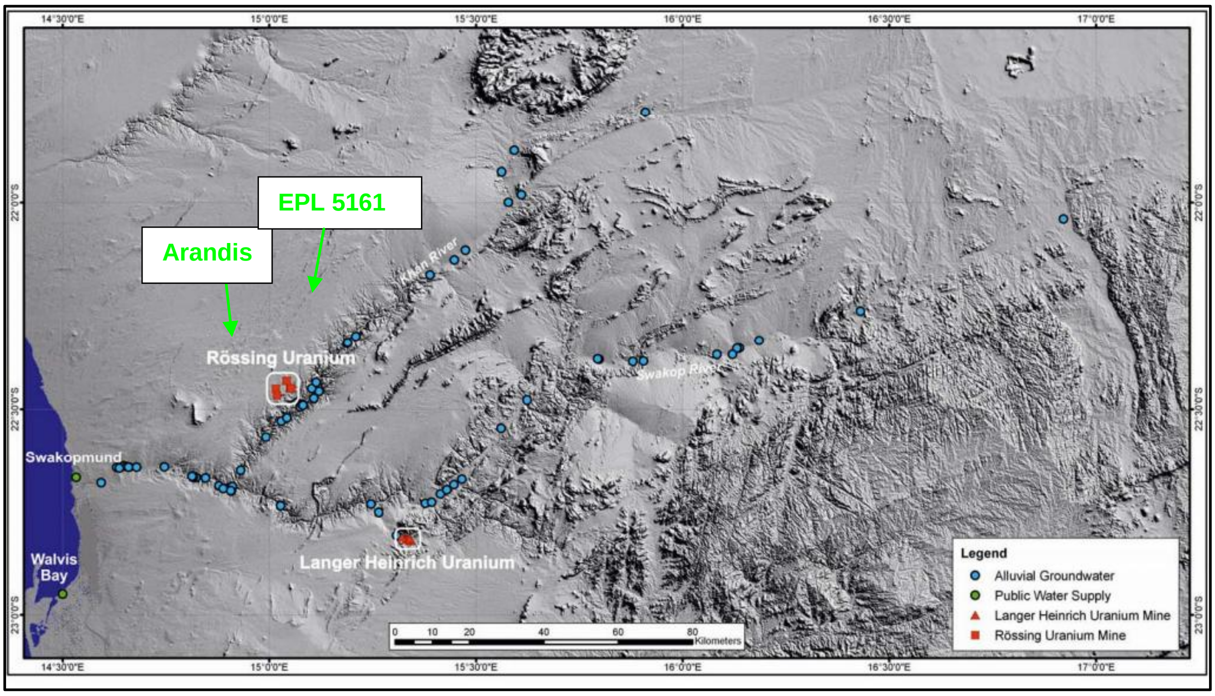


Figure 9:Location of the sampling points for the 2010 Khan-Swakop River Catchment groundwater quality assessment (edited after Kringel *et al*, 2010)

The spatial distribution of Electrical Conductivity (EC) from groundwater samples from this assessment (study) is shown in **Figure 10**. According to Kringel *et al* (2010), generally, the occurrence of low salinity groundwater is restricted to the headwater region of the two rivers. In the downstream region, groundwater is saline. For the Khan River catchment samples with high EC also occur upstream of any discharge point from the Rössing Uranium Mine. Elevated EC is also found upstream of the Langer Heinrich Uranium Mine. Apart from a few exceptions, samples east of 15.35° latitude are in group "excellent" (A) and "acceptable" (B) while to the west of this latitude the groundwater is in group C or lower, making it unsuitable for human consumption. **The unsuitability of this poor-quality water could also be explained by complaints received from some farm owners (about salty borehole water in the area) during the site visit on the 18th to 19th July 2020.**

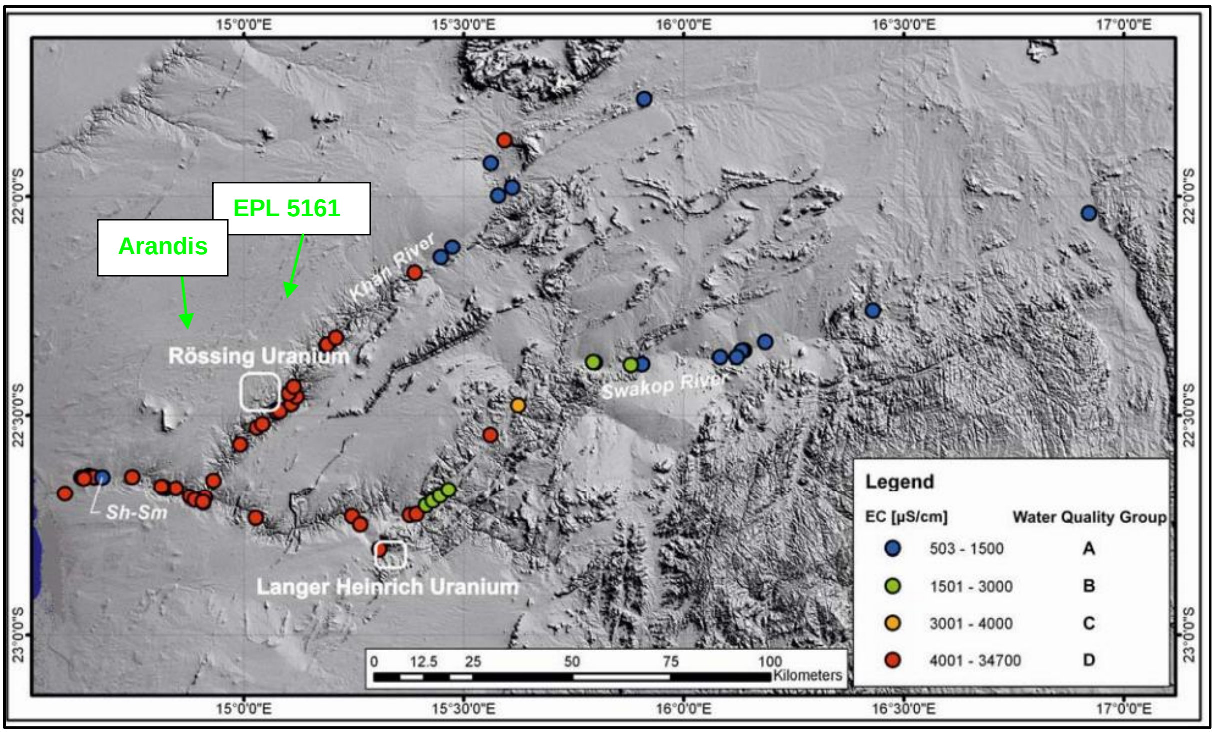


Figure 10: Spatial distribution of Electrical Conductivity (EC) at the sampled area (Kringel, 2010)

5.4.4 Vulnerability of Groundwater to Over-abstraction

The over-abstraction of groundwater in any aquifer in an area does not only affect the surrounding users (humans), but also the general environment (ecosystem) that depends on the same water resource. Over-abstraction would lead to significant lowering of groundwater levels in surrounding boreholes and the eventual gradual depletion of the aquifer. The lowering of the water table also means a decrease in borehole water levels for downstream water users. A decrease in water level in the surrounding (downstream) users' boreholes could increases pumping costs. This is true because advanced pumping equipment would be required to reach the new borehole water levels, thus affecting the rights of pre-existing water users in the area.

Groundwater over-abstraction does not only affect water users and the ecosystem, but also surface water-groundwater interactions which is a crucial component of the hydrologic cycle. Furthermore, over-pumping of groundwater would also induce the intrusion of salt water into the aquifer for aquifers in coastal areas, leading to poor water quality.

The water potential of the project site area, and this part of the Erongo Region is classified as generally low, locally moderate groundwater potential and in some further areas, very low and limited potential. The long-term unmanaged water abstraction from the aquifers with even moderate to good potential would still make the aquifers vulnerable to over-abstraction, therefore it would even be worse for aquifers with low to limited potential. However, the vulnerability of groundwater to over-abstraction would be dependent on the amount of water abstracted from the aquifer and frequency of abstraction.

With regards to the proposed water use on the project activities (without considering the existing water uses and with the absence of pre-project concerns), the nature and duration of the proposed project activities (specifically exploration being a short-term activity) as well as volume of water required, groundwater vulnerability to over-abstraction owing to the project activities is considered low to slightly moderate. The impact of the proposed project activities on the groundwater resources in the area is describe and assessed under Chapter 8.

5.4.5 Vulnerability of Site Area groundwater resources to Pollution

In areas where activities such as extensive agricultural, exploration and mining, waste management and industrial activities are practised with poor planning prior to project implementations, groundwater pollution becomes one of the main environmental and social concerns. However, as mentioned in the preceding subsection, poor water quality does not only come from direct pollution from the ground surface, but also from over-abstraction of aquifers, especially the poorly recharged and managed ones. Given the nature, type and scale of the proposed project activities, groundwater vulnerability to pollution owing to the project activities is rather low.

The Groundwater Resources Vulnerability Map of Namibia in **Figure 11** shows that the vulnerability of groundwater to pollution in the project area ranges from **rather low** to **moderate**. This vulnerability status could be explained by the geology of the site area that is mainly characterized by metamorphic rocks such as granites, dolerite, basalts, marbles, and schists. Groundwater is hosted in both these secondary aquifers (fractured or faulted rocks units) and at some places in unconsolidated sediments in this part of the Namib Desert. These rock units without any fractures/faults or joints are considered aquitards (rock units that restrict water flow or hardly transmit water from one rock unit to the other, which in a way would move pollution in the aquifer system, if present in the water).

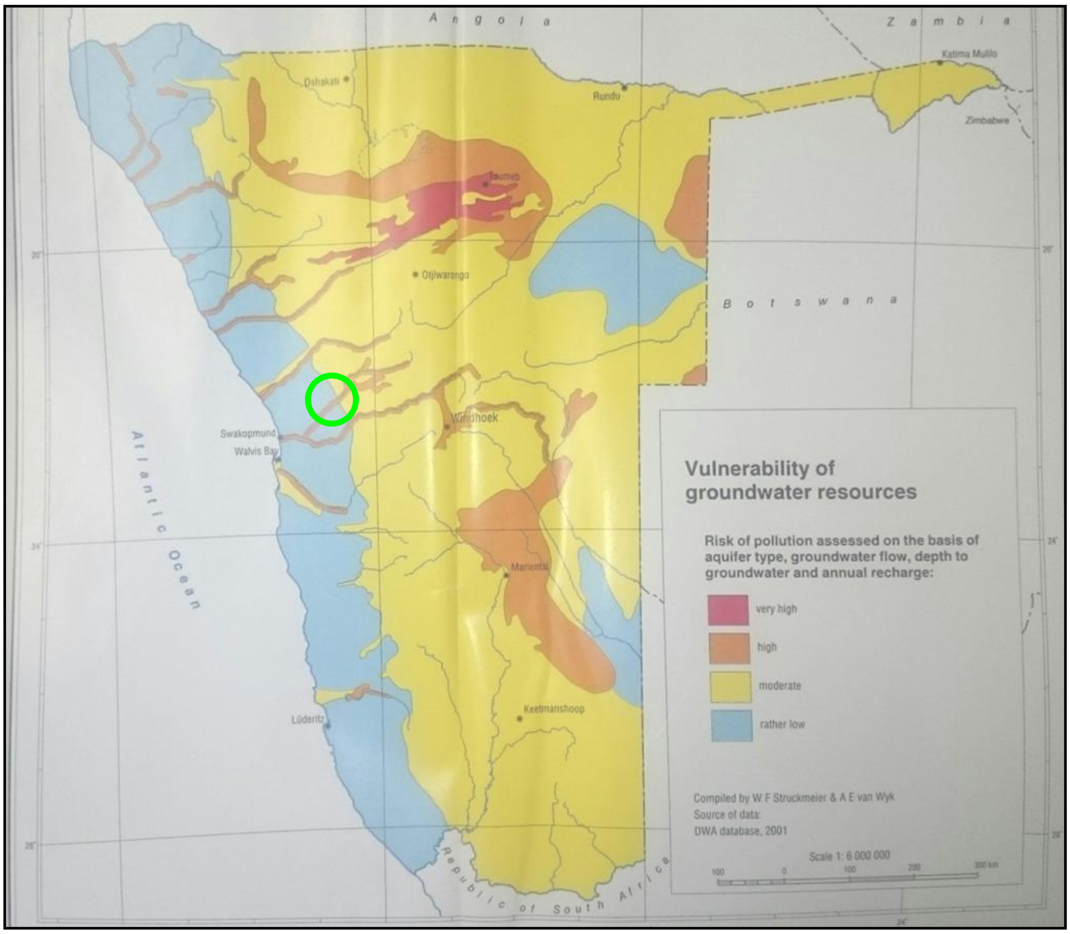


Figure 11: Vulnerability of groundwater resources to Pollution (Van Wyk et.al, 2001)- approximate project site area enclosed by the light green circle

5.5 Vegetation

The knowledge and consideration of vegetation cover in an area is crucial as evapotranspiration is one of the important components of the hydrologic cycle, and mostly on groundwater recharge. It is therefore vital to understand the vegetation cover in an area of interest.

According to Jacobson *et al* (1995), variation in rainfall is the primary determination of the western catchment vegetation. The classification of Giess (63) provides a broad overview of vegetation types found in the western catchments. The mountainous highlands associated with the headwaters of the Swakop and Kuiseb catchments, the highland savanna is composed of a complex mixture of *Acacia* species along with *Combretum*, *Euclea*, *Rhus* and perennial and annual grass species (Jacobson *et al*, 1995).

Moving westward off the inland plateau and towards the Namib Desert, the vegeation shifts from upland savannas to vegetation more suited to arid conditions. The transition zone between savanna and semi-desert is composed of a great variety of species, many of which are endemic to the Erongo Region (Jacobson *et al*, 1995). These vegetation species include *Euphorbia*, *Cyphostemma*, *Moringa*, *Adenolobus*, and *Acacia*.

The common vegetation on and around the project site area include quiver trees (A*loidendron dichotomum*), camelthorns (*Acacia erioloba*) and cactus (*Cactaceae juss*).

Since the purpose of this report is to assess the impact of the proposed project exploration activities on groundwater, certain factors need to be considered first prior to the actual assessment. Therefore, firstly the volume of water required for the project activities need to be known or at least estimated (Chapter 6) to make sound assessments of the potential impact and conclusions on the natural resource.

6 EXISTING AND PROPOSED WATER ABSTRACTION AND USE

6.1 Existing Groundwater abstraction and Use

Groundwater in the sub-catchments is used for stock watering, industrial, mining, tourism, and domestic consumption. Water required by commercial water users such as mining and for urban consumption such as towns with the broader catchment is abstracted from the Omaruru Delta Aquifer (Omdel) near Usakos. From here, operated and managed by NamWater, the water is channelled via pipelines to reservoirs for distribution to these different consumers. The catchment includes towns such as Arandis, Usakos, Swakopmund and Henties Bay.

Current water supply sources in Erongo's coastal region are the Omdel and Kuiseb Aquifers and the desalination plant built and owned by Areva. The Omdel dam, and aquifer recharge scheme was completed in 1994 but its sustainable yield is not fully understood. Based on the water figures in 2000, NamWater calculated that it has a sustainable yield of 9.8 Mm^3/a. Water Scarcity Solutions estimated the extractable recharge of Omdel to be about 7.1 Mm^3/a (Aurecon Environment and SLR Environmental Consulting, 2014).

According to Aurecon Environment and SLR Environmental Consulting (2014), the domestic demand in the coastal region is estimated to be 12.4 Mm^3/a in 2014 and could rise to 14.7 Mm^3/a by 2018. The demand in the mining and industrial sectors is predicted to be 5.4 Mm^3/a in 2014 and could rise to 13.7 Mm^3/a by 2018 with just the certain users, including Rossing Mine. When these demand predictions are balanced with the supply, including being supplied 10 Mm^3/a from Areva, there could be a shortfall of about 5 Mm^3/a in 2016 which would rise to 8 Mm^3/a from 2017 (Aurecon Environment and SLR Environmental Consulting, 2014).

With regards to the Arandis Town, the terminal reservoir capacity is 60 000 m^3 (comprised of three 20 000 m^3 reservoirs), and the Rossing Uranium Mine has access to 48 000 m^3 or 80% of this stored capacity. The low-level limit is set at 30% of full level, which translates to 6 000 m^3 of unusable storage in one reservoir. By adding 2 days of working storage and 2 days of emergency storage for Arandis a further 6 000 m^3 of storage is rendered unavailable. This adds to make a total of 12 000 m^3 reserved for Arandis, and the remaining 48 000 m^3 for the Mine (Aurecon Environment and SLR Environmental Consulting, 2014).

Based on the information gathered on site during the visit conducted on 18 July 2020, the borehole water in the area is salty and therefore not fit for human consumption. The water from local site boreholes is currently used for stock watering. Water for drinking is carted into the area and stored in tankers on farms. The carted water is provided by AREVA as part of their operations' social responsibilities.

The above water figures have been provided to give a general outlook on the groundwater consumption by major users (towns, industries, and mines) in the Erongo Region. This water is however not abstracted from the project site area but from the Omdel aquifer because the project site area's hydrogeological settings (potential) cannot yield nor cater for such huge volumes of water. The proposed exploration activities will therefore be solely supplied with water from the same schemes that supply Swakopmund (as mentioned under the next section).

With the above said, it can be assumed that the local aquifers around the project site (**catchments)** are only abstracted by potentially existing small-scale miners and farmers for their stock watering water needs (cumulative water abstraction and use). **It should also be noted that due to lack of baseline information on local water use, the total volume of water consumption by local activities that rely or depend on these aquifers is unknown.**

6.2 Proposed Water abstraction and Use for the Project Activities

The Proponent anticipates the use of water volumes within the range of 3 000 and 6 000 litres of water (i.e. 3 and 6 m^3) per day, averaging to a monthly volume of 93 000 and 186 000 litres (93 and 186 m^3/month). In case that the exploration activities would be carried out for a year or more, the annual water demand would be 1 116 and 2 232 m^3 (1 116 000 and 2 232 000 litres). The water required for this project will be mainly used for down-the-hole drilling, butterfly cutting during exploration, cleaning, and cooling off drilling/exploration equipment. Water recycling will be prioritized to conserve water.

A worst-case scenario of the water requirements, a daily volume of 5 000 litres will be used for this report's considerations and as maximum for the proposed project activities. This value would amount to an average of 155 000 litres per month (1 860 m^3 or 1 860 000 litres per year). It is important to note that this water will not be abstracted from existing site boreholes but carted from outside the project area (from a water supply line in Swakopmund or Karibib) and stored in industry standard water tanks on site for project use. Sufficient water from the outside area supply will be carted to site on certain days of the week only (not every day). This is to ensure the Proponent's water trucks are not traveling on the local and regional roads daily which would exert pressure on and impact the roads (traffic).

With this said, there will be no water abstraction from the local aquifers.

It is very important to determine or at least estimate the amount of water resource that is available in a certain area, as this helps in setting up management plans for the resource. This would usually be done by undertaking a preliminary groundwater reserve estimation for an area to determine the available abstractable (sustainable) water volume. The sustainable water volumes would be calculated from the (sub) catchment water balance and then determine the stress index level of the aquifer for the study/project area.

Since there will be no water abstraction from the catchment for exploration activities, there will be no need to calculate the available groundwater reserve (reserve estimation) of the area. However, it is vital to delineate the project catchment area and obtain crucial information such as sub-catchment and catchment areas and direction of potential flow in events of pollution from the sites. This information is given under the next chapter.

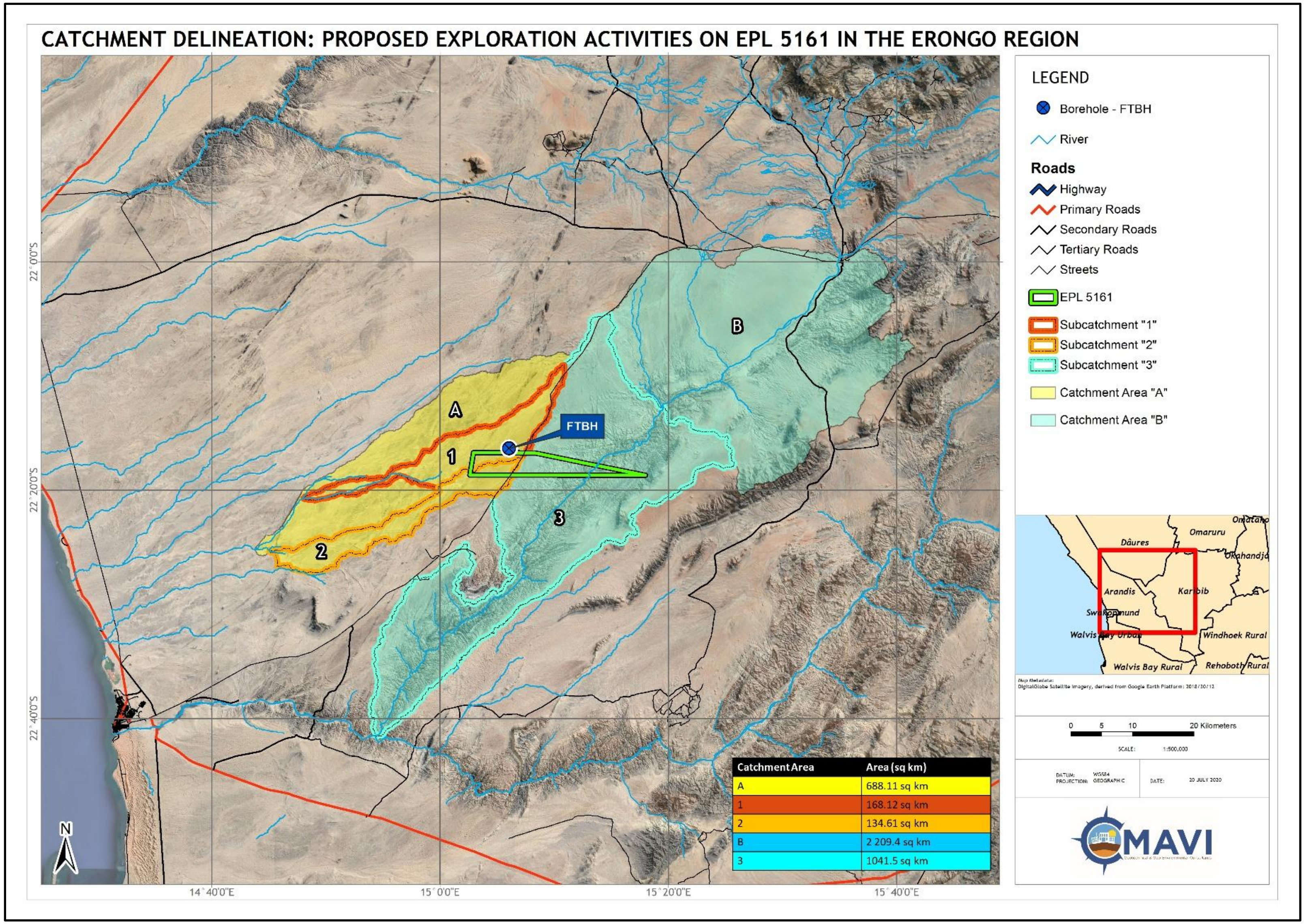
7 SUB-CATCHMENT DELINEATION

The project site was delineated by using ArcGIS. The digital elevation model (DEM) was used as an input to enable the delineation of a drainage system and then quantify the characteristics of that system. The tools in the extension allows the user to determine, for any location in a grid, the upslope area contributing to that point and the down slope path that would be followed by the water. This data is usually important during impact assessments.

According to Robins (2020), groundwater flows on a catchment scale from beneath the higher ground towards the lower ground to discharge as baseflow into the surface waters. The speed of the flow is a function of the hydraulic gradient, or the inclination of the water table, and the permeability or transmissive properties of the rocks. The volume of groundwater in the flow system depends on the effective rainfall, which is the actual rainfall minus evaporation, less any surface water runoff.

With that said, a site sub-catchment delineation map was created for the EPL site area and is shown in **Figure 12**. As it can be seen in the map, the EPL area falls into three different sub-catchments of the main catchments. These sub-catchments are labelled in the map as sub-catchment ‘’1’’, Sub-catchment ‘’2’’ and sub-catchment ‘’3’’. The sub-catchments (surface areas) will be used in the calculations to estimate the reserves of the site area. The surface areas of the sub-catchment ‘’1’’, ‘’2’’ and ‘’3’’ are 168.12 km^2, 134.61 km^2 and 1 041.50 km^2, respectively.

The significant identified borehole near the EPL site (Farm Trekopje) is also included in the sub-catchment map and falls under the delineated sub-catchment ’1’’ of the larger catchment A.



Catchment Area	Area (sq km)
A	688.11 sq km
1	168.12 sq km
2	134.61 sq km
B	2 209.4 sq km
3	1041.5 sq km

Figure 12: Sub-catchment delineation map for the EPL site area

The following chapter (Chapter 8) covers the potential impacts of the proposed exploration activities on groundwater, with primary focus on possible over-abstraction and pollution. Under the same chapter, these two aspects are described, and assessed (section 8.2 and 8.3).

8 GROUNDWATER IMPACTS: DESCRIPTION AND ASSESSMENT

8.1 General Concept of Impact (Risk) Assessment

Generally, an environmental risk occurs when there is a hazard (e.g. process, activity, or substance) that can result in a harmful impact on the surrounding environment. The part of the environment which is, or could be, affected is known as a receptor. Receptors include humans, flora and fauna, the built environment and water resources (controlled waters).

According to SRK (2006), the presence of a hazard alone does not constitute a risk; a risk is only present if there is a means by which the hazard can impact on sensitive receptor(s). The connection between the hazard and receptor is known as a pathway, and all three elements together constitute a source-pathway-receptor (S-P-R) linkage. The three elements are briefly defined as follows:

- **Source (or hazard)**: a substance capable of causing pollution or harm.
- **Receptor (or target)**: something which could be adversely affected by the contaminant.
- **Pathway**: a route by which contaminants can reach the receptor.

The environmental risk assessment is the process whereby S-P-R linkages are identified and assessed. In the case that any of the three elements are absent, then there is no complete linkage and thus no verifiable unacceptable risk. The magnitude of a risk is a function of the consequences of risk and the likelihood that such rick will occur.

The risk/impact assessment for the three identified potential impacts that may impact the water resources during the duration of the project activities is presented under the subsections below. The subsections provide a brief description to each potential impact (as per the S-P-R system) and then assessed according to the criteria provided (for both the pre-mitigation and post mitigation scenarios) under section 3.2.2 and 3.2.3.

8.2 Groundwater Impact Assessment (Over-abstraction)

Groundwater resources is impacted by project developments/activities in two ways, namely through pollution (water quality) or over-abstraction (water quantity) or at times both.

Based on the groundwater potential map, it could be clearly seen that groundwater resources in the project area are already scarce. The abstraction of more water than it can be replenished from an area with low and limited groundwater potential would negatively affect the local communities (farmers) that depend on the same ("struggling") groundwater resource (aquifer) and low yielding boreholes.

8.2.1 Brief Impact Description – Water Quantity

The impact of the exploration activities on the resources would be dependent on the required volumes of water. Commonly exploration activities use a lot of water, mainly in drilling. However, this depends on the type of drilling methods employed (diamond drilling is more consuming compared to drilling methods such as reverse circulation for instance) and the type of mineral being explored for.

The drilling method to be employed for this project's exploration activities is down-the hole (DTH). According to Jeansson (2014), water is required and used to power the impact mechanism of the hammer at a high frequency rate and bring any cuttings to the surface and clean the borehole. Additionally, the hydrostatic column, which is created above the hammer, helps to keep the hole stable while preventing potential collapse. This also prevents water from being drawn into the borehole, which increases hole stability and prevents potential environmental issues. Using water as a flushing medium also has a secondary effect in terms of borehole cleaning. This is important if the purpose of the borehole is for injection of cement (grouting) for ground improvement. Dust (compressed air + cuttings) clogs cracks, while the water cleans the borehole. This increase both productivity and quality in the grouting process. Water also acts as a lubricant and eliminates the need for any oil. This means that the ground is not polluted and workers or people in the vicinity are not exposed to oil mist or dust caused by the drilling process (Jeansson, 2014).

The required water for exploration (5 000 litres per day) will be used for drilling purposes and cooling drilling equipment. Given the low groundwater potential of the project site and area, the required water will be carted into the area from outside. The proposed option will be to supply the project from an outside area water supply in Swakopmund or Karibib and stored in industry standard water reservoirs/tanks on site. Although exploration may be requiring a lot of water, this would also be dependent on the duration of the exploration works and number of exploration boreholes required to make reliable interpretation on the commodity explored for.

In terms of water abstraction and use, the project activities will not use a significant amount of water that would impact the already struggling resources in the area, because no groundwater abstraction will be done during exploration works. Therefore, no pressure (or threat) to the local aquifers in terms of water quantity (abstraction).

The assessment of this potential impact on water abstraction from the aquifers is summarized as follows:

- **Source:** The sources in this aspect would be the over-abstraction from the aquifers, which could affect other water users and the environment. **However, there is no anticipated local groundwater abstraction from these proposed project activities, as the required water will be carted into the area.**

- **Pathway:** The pathway is determined by the depth to water table, type of lithology in the area and groundwater flow direction. **In the case of water abstraction from local aquifers(boreholes), the impact is none because the project site's groundwater is mainly hosted in the above-mentioned rock units, therefore, rapid drawdown is unlikely and <u>no water will be abstracted from the local boreholes</u>.**
- **Receptor:** The neighbouring farms (boreholes) and other water users (downstream to the west) and surrounding environmental components like vegetation could be considered potential receptors. **However, this will not be experienced owing to the project activities because there will be no local groundwater abstraction.**

Furthermore, based on the impact assessment criteria presented under the Methodology chapter, this impact has been assessed as follows (**Table 3**).

Table 3: Assessment of the project impact on water resources abstraction (quantity)

Mitigation Status	Extent	Duration	Intensity	Probability	Significance
Pre mitigation	L/M - 2	M - 3	L/M - 4	L/M - 2	L -18
Post mitigation	L -	L - 1	L - 2	L - 1	L - 4

8.3 Groundwater Impact Assessment (Pollution)

8.3.1 Brief Impact Description – Water Quality

In areas where activities such as extensive agricultural, mining, waste management and industrial activities are practiced with poor planning prior to project implementations, groundwater pollution becomes one of the main environmental and social concerns. However, as mentioned in the preceding subsection, poor water quality does not only come from direct pollution from the ground surface, but also from over-abstraction of aquifers, especially the poorly recharged and managed ones. Given the nature, type and scale of the proposed project activities, groundwater vulnerability to pollution owing to the project activities is rather low.

The anticipated potential source of pollution to groundwater resources from the project activities would be hydrocarbons (oil) from project (exploration) vehicles, machinery, and equipment as well as potential wastewater/effluent from exploration works. The spills (depending on volumes spilled on the soils) from these machinery, vehicles and equipment could infiltrate into the ground and pollute the already shallow and permeable aquifers on site, and with time reach further groundwater systems in the area.

The Groundwater Resources Vulnerability Map of Namibia in **Figure 11** shows that the vulnerability of groundwater to pollution in the project area ranges from rather low to moderate. This vulnerability status could be explained by the geology of the site area that is mainly characterized by metamorphic rocks such as granites, dolerite, basalts, marbles, and schists. Groundwater is hosted in both these secondary aquifers (fractured or faulted rocks units) and at some places in unconsolidated sediments in this part of the Namib Desert. These rock units without any fractures/faults or joints are considered aquitards (rock units that restrict water flow or hardly transmit water from one rock unit to the other).

8.3.2 Pollution Impact Assessment

The main concern regarding groundwater pollution would be on areas that are underlain by fractured/faulted rock units or partly overlain by the limited sediments. These sediments or fractured rock structures would provide ready passage for pollutants into groundwater, but without faults or fractures, these rock units would behave as aquitards, but not aquifers. If there is a significant point source of pollution, the pollution vulnerability would be bound to fractured/faulted rock units, therefore low (for fractured/faulted rocks) and slightly moderate (for distinctive unconsolidated sediment aquifer areas).

Furthermore, although not significant, measured nor monitored, there could already be an existing pollution from other pre-proposed project (existing) anthropogenic activities undertaken in the site area. These existing activities or some of them could also have been the sources of such pollution. Therefore, it is of great importance to first assess the baseline (water quality) information pre-exploration activities so that future pollution scenarios will not be solely pointed to the proposed project activities, **but to also consider the possibility of cumulative occurrence of such an impact (pollution) in the area**. Groundwater pollution risk can also arise from localized pollution sources, in combination with the aquifer's vulnerability to pollution.

Overall, the likelihood of significant pollution to groundwater in the project area is low due known low rainfall in the area and eventually little to no groundwater recharge, which could carry polluted water into the local aquifers.

The potential impact of pollution arising from the proposed project is described below as per the three elements of risk/impact assessment given under Section 8.1:

- **Source:** As mentioned above, potential sources of pollution from the project activities would be hydrocarbons (oil) from project (exploration) vehicles, machinery, and equipment as well as potential wastewater/effluent from exploration works.

Further cumulative sources of pollution are wet waste/effluent from improperly managed sewage facilities, fertilizers, pesticides, and hydrocarbons from other existing anthropogenic activities in the site area. Another **significant potential (cumulative) source of pollution in the area is the material from the tailings storage facility (TSF) at Rössing Mine (subject to capping, so that fresh material deposited onto the TSF forms a solid crust after a period of a few months). According to von Oertzen (2015), after this, very little material can be mobilized by wind from this surface. This means that it is the freshly deposited and dried material on the TSF that is most likely to be mobilized by wind. Dust that has been deposited in the plume during the season of east wind tends to have formed a hard crust by the time the next east wind season occurs, and very little further distribution of this material then occurs through wind erosion. Further mobilization of this material now occurs through water erosion during infrequent rainstorm events, which collect dust from the surface and accumulate the material in gullies. Water erosion therefore collects material which was distributed in a thin layer on the surface and gathers it in small accumulations in lower lying areas**. During heavy rainy seasons, these pollutants would be carried by rainwater through surface runoff and infiltrate into the ground, recharge local aquifer systems and pollute them.

- **Pathway**: Polluted or poor-quality water would travel from the potential sources (points) of pollution downstream of the sites in the project area. In some parts of the site areas that may be underlain by the porous and unconsolidated sediments (aquifers), these aquifers in these parts may be prone to pollution risk. Given the high permeability of such sediments, water can enter the groundwater system easily and rapidly. In events of high pollution on the surface, the nature of these sediments would be expected to cause rapid infiltration of pollutants to groundwater and spreading of pollutants over a large area. In parts of the project areas underlain by the consolidated rocks such as dolerite, basalts, schists and marbles, the pollution transport would not penetrate the aquifers. This could be because of the presence of these host rocks (if not fractured) that act as pollution barriers (aquitards), thus preventing or delaying any possible pollutant transport in groundwater.

- <u>Receptor:</u> **Should there be an excessive abstraction from the local aquifers,** the impact could be felt by communities and natural biophysical environments downstream depending on groundwater, and they would be considered potential receptors of this pollution from the exploration activities' sources. **A sudden worsened groundwater quality downstream during the project operations would at some extent be linked to the project activities. However, this would need to be verified against baseline water quality analysis data (results) recorded pre-exploration activities to prove that the experienced water quality issue has indeed been worsened by the exploration activities on the EPL. This would also be a challenge to prove because of the short lifespan of exploration activities and the slow movement of groundwater from one area to the other over time would mean that the impact would only be felt some time after the activities are completed. In other words, should the exploration activities end there (in this phase) without progressing to the mining phase where groundwater quality monitoring could be conducted.**

From the above description of the impact, it can be concluded that without implementing any measures to avoid or minimize the impact, the impact significance will moderate and once the mitigation measures have been implemented, the significance will be reduced to low. The assessment is also presented in **Table 4** below.

Table 4: Assessment of the project impact on groundwater resources (quality)

Mitigation Status	Extent	Duration	Intensity	Probability	Significance
Pre mitigation	M - 3	M - 3	L/M - 4	M - 3	M - 30
Post mitigation	L/M - 2	L/M - 2	L - 2	L - 1	L - 6

After assessing the site area based on the available information, literature and professional judgement, the impact of pollution on the groundwater resources, this impact is considered low. Furthermore, the project impact is short-term, i.e. the potential impact will only be existing during (limited to) this phase.

The next chapter (Chapter **9)** presents the groundwater abstraction management plans to ensure groundwater protection against over-abstraction (overexploitation) and potential pollution.

9 GROUNDWATER MANAGEMENT MEASURES

The following water management plans are recommended, and they should be effectively implemented and monitored by the project Proponent to mitigate and effectively manage the potential impacts on groundwater resources in the area.

9.1 Groundwater Abstraction Management Plans

Over-abstraction of both surface and groundwater resources can have severe impacts on people, animals and surrounding environment supported by the same water resource. Therefore, it is very important to manage water abstraction. If too much groundwater is abstracted, the aquifer may become depleted. The depletion of groundwater has adverse impacts like drying up of shallow water boreholes, deterioration of water quality and a decrease in groundwater levels, which results in increased water pumping costs (GCS Water & Environmental Consultants, 2016). It is therefore important to manage the abstraction from an aquifer.

However, there will be no anticipated abstraction from the local aquifers because the required water will be carted into the area from Proponent' supply line in Swakopmund that is fed by the main groundwater scheme(s) for Swakopmund and other coastal towns. Although the project water will be sourced from the said outside supply system, it is equally vital to ensure that certain water management measures are in place for implementation by all commercial water users, regardless of whether they directly abstract from the aquifer (natural resource) or supplied via a supply scheme. The following water use management plans are recommended to mitigate the impact of groundwater (over) abstraction on a larger scale:

- **Please note that it is unlikely that a Groundwater Abstraction and Use permit (license) would be required, therefore not significant. This is firstly because the Proponent will not be abstracting water directly from an aquifer but carted to site and secondly during the exploration, the activities will not be yielding any income i.e. not commercially valuable yet. Water use is limited to exploration activities only which is short-term. With this said, it will be very crucial for the Proponent to adhere to the actual water volumes required for the exploration activities even if they will not be abstracting directly from site boreholes.**
- The water user (Proponent) should consider voluntary water use reduction by sticking to the proposed daily threshold volume of **5 m^3 or 5 000 litres, which is 155 000 litres per month (5 000 litres x 31 days = 155 000 litres or 155 m^3). This amounts to 1 860 000 litres or 1 860 m^3 per year (155 m^3 x 12 months).**
- Sufficient water from outside the area should be carted to site on certain days and stored in onsite water tanks. This is to ensure the Proponent's water trucks are not traveling on the local and regional roads everyday which would exert pressure on and impact the services infrastructure such as roads during water transportation. This is to avoid taking from the outside area water supply line in Swakopmund or Karibib in large amounts every day and put unnecessary pressure on the main regional groundwater scheme supplies.

- Given the indication that some abstraction from the saline borehole at Trekkopje mine may occur to supplement carted water for exploration, if ''push comes to shelf'', the water abstracted from the borehole should also be used efficiently and enough should be abstracted just enough to augment the carted water. For instance, if the carted water can supply 3 000 litres (3 m^3) then the borehole can supply the remaining 2 000 litres (2 m^3) of the required volume, but only when deem necessary.
- The Proponent should implement water reuse/recycling methods as far as practicable. Water used to cool off exploration equipment should be captured and used for the cleaning of equipment if possible.
- Water conservation awareness and saving measures training should be provided to all the project workers so that they understand the importance of conserving water and become accountable.

9.2 Groundwater Pollution Management Plans

It is important to note that the potential pollution from the project does not constitute the absence of current (cumulative) and future anthropogenic activities that are already or will be contributing to groundwater pollution in the project area. Nevertheless, to avoid and or minimize the potential impact of pollution stemming from the project activities, the following measures are recommended for implementation:

- Exploration site areas where hydrocarbons will be utilized, the surface should be covered with an impermeable plastic liner (e.g. an HDPE liner), carefully placed so as to minimize risk of puncturing, to prevent any spillages from getting into direct contact with the soils and prevent eventual infiltration into the ground.
- Project machines and equipment should be equipped with drip trays to contain possible oil spills when operated during exploration works.
- All wastewater and hydrocarbon substances and other potential pollutants associated with the project activities should be contained in designated containers on site and later disposed of at nearby approved waste sites in accordance with MAWLR's Water Environment Division standards on waste discharge into the environment. This is to ensure that these hazardous substances do not infiltrate into the ground and affect the groundwater quality.
- In cases of accidental fuel or oil spills on the soils from site vehicles, machinery and equipment, the polluted soil should be removed immediately and put in a designate waste type container for later disposal as per the preceding bullet point. The removed polluted soil should either be completely disposed of or cleaned and returned to where it was taken from on site or can be replaced with a cleaner soil. This is to ensure that the pollutants contained int the soil does not infiltrate into the site soils and eventually reach to groundwater.

- Although fuel (diesel) required for exploration equipment will be stored in a tank or tanks mounted on a mobile trailer, drip trays must be readily available on this trailer and monitored to ensure timely cleanup of accidental fuel spills along the tank trailer path/route around the exploration sites. This all aimed at preventing accidental fuel spills or leaks from spreading to the soil and eventually to groundwater.
- Spill control preventive measures should be in place on site to management soil contamination, thus preventing and or minimizing the contamination from reaching groundwater bodies. Some of the soil control preventive measures are:
    - Identification of oil storage and use locations on site and allocate drip trays and polluted soil removal tools suitable for that specific surface (soil or hard rock cover) on the sites.
    - Maintain equipment and fuel storage tanks to ensure that they are in good condition thus preventing leaks and spills.
    - The oil storage and use locations should be visually inspected for container or tank condition and spills.
    - Maintain a fully provisioned, easily accessed spill kit. Spill kits should be located throughout the active project sites contain the floor dry absorbent material and absorbent booms, pads, mats. These would be suitable for ground surface areas that are covered mainly by hard rocks.
    - All project employees should be made aware of the impacts of soil pollution and advised to follow appropriate fuel delivery and handling procedures.
    - Develop and prepare countermeasures to contain, clean up, and mitigate the effects of an oil spill. This includes keeping spill response procedures and a well-stocked cache of supplies easily accessible.
    - Ensure employees receive basic Spill Prevention, Control, and Countermeasure (SPCC) Plan training and mentor new workers as they get hired in each phase of the project.

The recommendations and conclusions made for the overall assessment are as presented under Chapter 10 below.

10 RECOMMENDATIONS AND CONCLUSIONS

The aim of this report was to identify and assessed the potential impacts of the proposed exploration activities on the groundwater resources. The assessment has been undertaken on a desktop level, i.e. based on project information provided by Omavi Consultants (the project Environmental Assessment Practitioner), author’s review of previous and available different relevant studies conducted in the project area by other consultants and relevant information from data sources in the field of groundwater.

The recommendations provided to the assessment and conclusions made are presented under the following sections (10.1 and 10.2):

10.1 Recommendations

Given the assessment results, to manage and protect the water resources, the following management measures should be implemented:

Groundwater Abstraction and Use Mitigation Measures

- **Please note that it is unlikely that a Groundwater Abstraction and Use permit (license) would be required, therefore not significant. This is firstly because the Proponent will not be abstracting water directly from an aquifer but carted to site and secondly during the exploration, the activities will not be yielding any income i.e. not commercially valuable yet. Water use is limited to exploration activities only which is short-term. With this said, it will be very crucial for the Proponent to adhere to the actual water volumes required for the exploration activities even if they will not be abstracting directly from site boreholes.**
- The water user (Proponent) should consider voluntary water use reduction by sticking to the proposed daily threshold volume of **5 m^3 or 5 000 litres, which is 155 000 litres per month (5 000 litres x 31 days = 155 000 litres or 155 m^3). This amounts to 1 860 000 litres or 1 860 m^3 per year (155 m^3 x 12 months).**
- Sufficient water from outside the area should be carted to site on certain days and stored in onsite water tanks. This is to ensure the Proponent's water trucks are not traveling on the local and regional roads everyday which would exert pressure on and impact the services infrastructure such as roads during water transportation. This is to avoid taking from the outside area water supply line in Swakopmund or Karibib in large amounts every day and put unnecessary pressure on the main regional groundwater scheme supplies.
- Given the indication that some abstraction from the saline borehole at Trekkopje mine may occur to supplement carted water for exploration, if ''push comes to shelf'', the water abstracted from the borehole should also be used efficiently and enough should be abstracted just enough to augment the carted water. For instance, if the carted water can supply 3 000 litres (3 m^3) then the borehole can supply the remaining 2 000 litres (2 m^3) of the required volume, but only when deem necessary.
- The Proponent should implement water reuse/recycling methods as far as practicable. Water used to cool off exploration equipment should be captured and used for the cleaning of equipment if possible.
- Water conservation awareness and saving measures training should be provided to all the project workers so that they understand the importance of conserving water and become accountable.

Groundwater Pollution Mitigation Measures

- Exploration site areas where hydrocarbons will be utilized, the surface should be covered with an impermeable plastic liner (e.g. an HDPE liner), carefully placed so as to minimize risk of puncturing, to prevent any spillages from getting into direct contact with the soils and prevent eventual infiltration into the ground.
- Project machines and equipment should be equipped with drip trays to contain possible oil spills when operated during exploration works.
- All wastewater and hydrocarbon substances and other potential pollutants associated with the project activities should be contained in designated containers on site and later disposed of at nearby approved waste sites in accordance with MAWLR's Water Environment Division standards on waste discharge into the environment. This is to ensure that these hazardous substances do not infiltrate into the ground and affect the groundwater quality.
- In cases of accidental fuel or oil spills on the soils from site vehicles, machinery and equipment, the polluted soil should be removed immediately and put in a designate waste type container for later disposal as per the preceding bullet point. The removed polluted soil should either be completely disposed of or cleaned and returned to where it was taken from on site or can be replaced with a cleaner soil. This is to ensure that the pollutants contained int the soil does not infiltrate into the site soils and eventually reach to groundwater.
- Although fuel (diesel) required for exploration equipment will be stored in a tank or tanks mounted on a mobile trailer, drip trays must be readily available on this trailer and monitored to ensure timely cleanup of accidental fuel spills along the tank trailer path/route around the exploration sites. This all aimed at preventing accidental fuel spills or leaks from spreading to the soil and eventually to groundwater.
- Spill control preventive measures should be in place on site to management soil contamination, thus preventing and or minimizing the contamination from reaching groundwater bodies. Some of the soil control preventive measures are:
    - Identification of oil storage and use locations on site and allocate drip trays and polluted soil removal tools suitable for that specific surface (soil or hard rock cover) on the sites.
    - Maintain equipment and fuel storage tanks to ensure that they are in good condition thus preventing leaks and spills.
    - The oil storage and use locations should be visually inspected for container or tank condition and spills.
    - Maintain a fully provisioned, easily accessed spill kit. Spill kits should be located throughout the active project sites contain the floor dry absorbent material and absorbent booms, pads, mats. These would be suitable for ground surface areas that are covered mainly by hard rocks.
    - All project employees should be made aware of the impacts of soil pollution and advised to follow appropriate fuel delivery and handling procedures.

- Develop and prepare countermeasures to contain, clean up, and mitigate the effects of an oil spill. This includes keeping spill response procedures and a well-stocked cache of supplies easily accessible.
- Ensure employees receive basic Spill Prevention, Control, and Countermeasure (SPCC) Plan training and mentor new workers as they get hired in each phase of the project.

10.2 Conclusions

Water abstraction (use): Water abstraction (use): The impact on local groundwater resources (abstraction) will be none because no groundwater will be abstracted from the local aquifers of the project magnitude (small to medium as the required water will be carted into the area. Therefore, the impact on groundwater resources (quantity) from the exploration activities is non-existent, provided that the Proponent strictly uses carted water and not abstract from the local boreholes.

Water pollution: As it is common with every new and existing project, ground surface pollution is anticipated from the project operations and related activities. This potential pollution would be from improper disposal of hazardous products such as hydrocarbons (fuel/oils) and effluent from exploration works on site. The geology of the project area would make the groundwater less vulnerable to pollution from the surface due to the type (igneous and metamorphic rocks) and nature (unfractured/faulted) of rocks would inhibit further spreading pollution of potential pollutants in the water. The avoidance of pollution from reaching the ground surface (into groundwater) and effective implementation of pollution management plans will greatly aid in minimizing groundwater pollution. The impact is therefore considered low (minimal) to slightly moderate and according to the Groundwater Resources Vulnerability to pollution Map, the general site area has a rather low and, in some parts, moderate risk of pollution.

Furthermore, the potential pollution impact is short-term (short lifespan), as it will only be existing during the duration of exploration activities, which means that the impact will be only limited to the duration of the proposed activities.

In conclusion, the proposed project activities will not impact the local groundwater resources therefore the impacts' significance will be none for water quantity (no direct abstraction from local boreholes) and low to slightly medium (for water quality). Therefore, it is vital for the Proponent and their contractors (if any) to effectively implement and monitor the recommended management measures to protect both the biophysical and social water environment. All these would be done with the aim of promoting environmental sustainability while ensuring a smooth and harmonious existence and purpose of the project activities in the hosting biophysical and social environment.

To protect groundwater, it is necessary for different water users in societies to recognize that water resources are finite and vulnerable and find ways to reconcile the demands of human activities with the tolerance of nature. The essential first step to making water use sustainable is awareness and knowledge of human impacts on the environment, specifically on water resources. This will not only be applicable to the project proponents but also members of the public who may have been living in the area prior to developments, such as the proposed exploration.

The Proponent will also be required to ensure that all their activities comply with the legislation governing their project activities with respect to groundwater resources management and protection.

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