# ENVIRONMENTAL PERFORMANCE REPORT AND MANAGEMENT PLAN FOR WATER ABSTRACTION BOREHOLES ON FARM FINSTERBERGEN

**Farm Finsterbergen, Oshikoto Region**

**OCTOBER 2019**

SLR Project No.: 733.19137.00002
Report No.: 2
Revision No.: 2
October 2019

SLR

# DOCUMENT INFORMATION

| | |
|---|---|
| Title | Environmental Performance Report and Management Plan for Water Abstraction Boreholes on Farm Finsterbergen |
| Project Manager | Marvin Sanzila |
| Project Manager e-mail | msanzila@slrconsulting.com |
| Author | Marvin Sanzila & Ester Gustavo |
| Reviewer | Matthew Hemming & Edward Perry |
| Keywords | Environmental Management Plan, Water Abstraction Boreholes, Farm Finsterbergen |
| Status | Final |
| SLR Project No | 733.12053.00001 |
| Report No | 2 |

# DOCUMENT REVISION RECORD

| Rev No. | Issue Date | Description | Issued By |
|---|---|---|---|
| 1 | July 2019 | First Draft | EG |
| 2 | October 2019 | Final Report | MS |

# BASIS OF REPORT

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# ACRONYMS AND ABBREVIATIONS

| Acronym / Abbreviation | Definition |
|---|---|
| DEA | Department of Environmental Affairs |
| DEM | Digital Elevation Model |
| DWAF | Department of Water Affairs and Forestry |
| ECC | Environmental Clearance Certificate |
| EIA | Environmental Impact Assessment |
| | |
| EMP | Environmental Management Plan |
| LDV | Light Diesel Vehicle |
| MAWF | Ministry of Agriculture, Water and Forestry |
| mbgl | Meters below ground level |
| MET | Ministry of Environment and Tourism |
| OML | Otavi Mountain Lands |
| RWL | Rest Water Level |
| SLR | SLR Environmental Consulting (Namibia) (Pty) Ltd |
| SRTM | Shuttle Radar Topographic Mission |
| T | Transmissivity |
| TCL | Tsumeb Corporation Limited |
| TGWS | Tsumeb Groundwater Study |

# 1 INTRODUCTION

## 1.1 PROJECT BACKGROUND

The Farm Finsterbergen 469 managed by Mr. Siegfried Kuhn is situated in the Otavi District in the Otjozondjupa Region (refer to Figure 1-1 for the regional setting). The farm was previously owned by Finsterbergen Holdings as an irrigation farm, and it has since 2017 been bought over by Marabu Trading (PTY) Ltd (Marabu Trading) also for the purposes of conducting an irrigation scheme.

The Marabu Trading has removed all livestock and has halted any irrigation until the renewal of groundwater abstraction permit has been approved and therefore, over the past three years, no irrigation has been conducted. Since the new owners have bought the farm, the current water abstraction permit No. 10179 is inherited and it was allocated to permit abstraction of 100, 000 $m^3$/a. The current permit has now expired as of June 2019 and subsequently a renewal application has been submitted to the Ministry of Agriculture, Water and Forestry's (MAWF) Department of Water Affairs (DWAF). The DWAF has indicated that the current permit holder (Finsterbergen Holdings) if needed may transfer ownership to Marabu Trading. However, all permit holders' requirements still apply.

The new owner (Marabu Trading) plans to continue with similar irrigation activities on the 46 ha of seed potatoes/tubers, maize and/or oats in the already disturbed land and expand its activities further to 150 ha.

Finsterbergen Holdings has recently drilled several boreholes on the farm with electrical installations for irrigation purposes. With the previous 46 hectares irrigated, the allocated 100,000 $m^3$/a, was sufficient. However, in the future planned phase 3 scenario a total of 150 ha is envisaged for irrigation by the year 2020, where the water demand increases to 843,480 $m^3$/a in the worst-case scenario of no rainfall. **The DWAF has indicated that a groundwater assessment study would have to be undertaken to substantiate the proposed increase in groundwater abstraction and an Environmental Clearance Certificate (ECC) application through the regulating authority made. DWAF will review and use the findings of the groundwater assessment study as a deciding tool for the requested increase in the annual abstraction and only then a renewal with the amended abstraction rates can be made.**

The above mentioned proposed increase in groundwater abstraction will be sourced from the recently drilled Five (5) new boreholes including WW 205370 (BH1), WW 205368 (BH2), WW 205369 (BH3), WW 205367 (BH4), and WW 205371 (BH5) (refer to Figure 1-2 for locality map to the boreholes)

The purpose of the project is to supply Namibian potatoes farmers with seed potatoes/ tubers, Namibia is a sole imported of seed potatoes. Other crops like maize will be delivered to Otavi Mills for food production; and oats to wildlife and cattle in events of droughts.

It is with the above background that Finsterbergen Holdings/ Marabu Trading has requested SLR Environmental Consulting (Namibia) (Pty) Ltd (SLR), to assist with:

- the application process required for an amendment to the current groundwater permit's (permit No. 10179) abstraction limit from 100,000 $m^3$/a to 843,480 $m^3$/a (sourced from the recently drilled boreholes (BH1-BH5) through the DWAF; and
- the Environmental Clearance Certificate (ECC) application from the Department of Environmental Affairs (DEA) of the Ministry of Environment and Tourism (MET).

In September 2019, SLR undertook a Groundwater Assessment Study for Farm Finsterbergen 469 to determine the possible impact of the proposed increased abstraction (100 000 $m^3$/a to 843,480 $m^3$/a) on the groundwater aquifer and surrounding area. The study findings including the proposed management and mitigation measures have been included in this report (refer to Sections 7, 8 and 9). The Groundwater Assessment Study is attached to this report as Appendix A. Based on the outcome of the Groundwater Assessment Study, a groundwater permit amendment application for the increased abstraction can be made to the DWAF.

## 1.2 ENVIRO-LEGAL CONTEXT

In terms of the Environmental Management Act, 2007 (Act No. 7 of 2007) and associated Environmental Impact Assessment Regulations, water abstraction for commercial purposes and irrigation schemes are listed activities which are regulated by the Ministry of Environment and Tourism (MET). The activity requires an Environmental Impact Assessment (EIA) process and an application for an Environmental Clearance Certificate (ECC). The listed activities refer to:

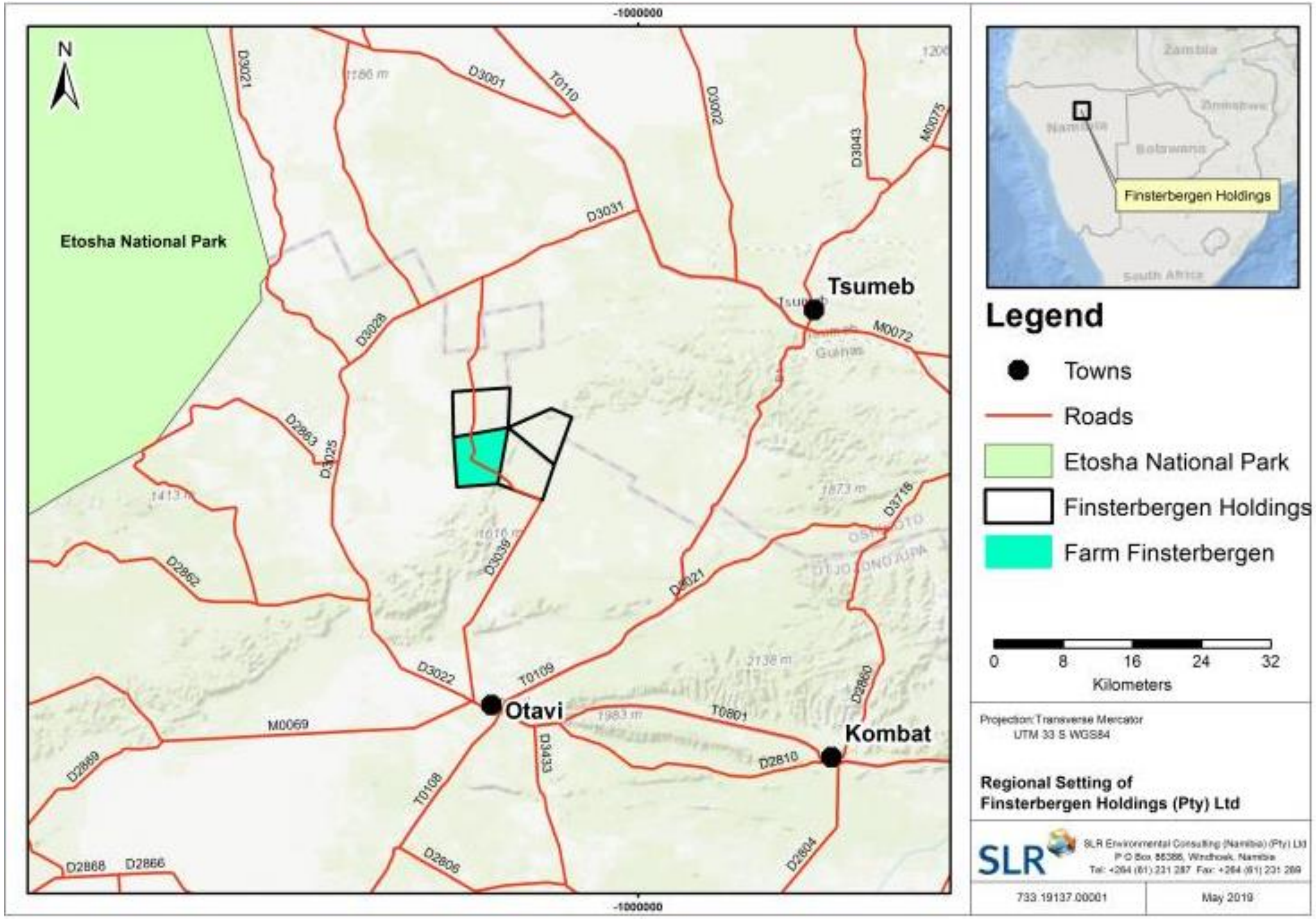
***WATER RESOURCE DEVELOPMENTS***

- *Activity 8.1:The abstraction of ground and surface water for the industrial or commercial purposes;*
- *Activity 8.2: The abstraction of groundwater at a volume exceeding the threshold authorized in terms of law relating to water resources;*
- *Activity 8.7: Irrigation schemes for agriculture excluding domestic irrigation.*

The MET were consulted on the possibility of making application for an exemption from for the need for an Environmental Clearance Certificate (ECC) for the increased groundwater abstraction activity on Farm Finsterbergen. **The MET rejected the ECC exemption application and requested that an assessment for the proposed increase in abstraction, supported by an Environmental Management Plan (EMP), should be submitted for review and decision on an ECC.**

It is with this background that SLR provides this report giving the following;

- a description of current infrastructure and activities at Farm Finsterbergen boreholes (BH1- BH5) observed during a site visit on the 18th of April 2019;
- details of the existing borehole monitoring programme;
- consideration of current environmental performance and risks;
- and mitigation measures associated with:
    - the proposed increase in ground water abstraction level (100 000 $m^3$/a to 843,480 $m^3$/a) as detailed in the Groundwater Assessment Study (Appendix A);
    - the ground water abstraction activities including, monitoring and the maintenance of infrastructure thereof.;
    - The existing irrigation and associated activities on the further extent of the land (49 ha to 150 ha);




## FIGURE 1-1: REGIONAL SETTING OF FINSTERBERGEN HOLDINGS (PTY) LTD


**FIGURE 1-2: LOCALITY MAP TO FARM FINSTERBERGEN SHOWING RECENTLY DRILLED BOREHOLES (BH1- BH5)**

# 2 BASELINE ENVIRONMENT

Information provided in this section is only relevant to the existing borehole locations/ setting and the water abstraction activity. Additional baseline is detailed in the SLR report for the Groundwater Assessment Study (Appendix A).

## 2.1 TOPOGRAPHY AND DRAINAGE

Farm Finsterbergen is located 30 km north north-west of Otavi and 40 km south west of Tsumeb, within the Cuvelai-Etosha Basin catchment, which is an endoreic drainage system where runoff flows from all sides into the Etosha Pan from where it then mostly evaporates. The topography consists predominantly of isolated dolomitic hills with karstic features due to the dissolution of carbonaceous base rock (mainly dolomite and limestone) in this area; the area is characterised by underground drainage systems with sinkholes, crevasses and caves. It is observed that areas south of Farm Finsterbergen has higher elevation, up to 2120 m amsl, in comparison to areas further north where elevation drops to 1020 m amsl (Figure 2-1).

Due to the geology of the area, there is no well-defined drainage pattern in the Otavi-Tsumeb area, but rather many small individual drainage systems forming from the isolated hills. No major surface runoff is observed due to rapid intake of water by the karstic features in most areas.

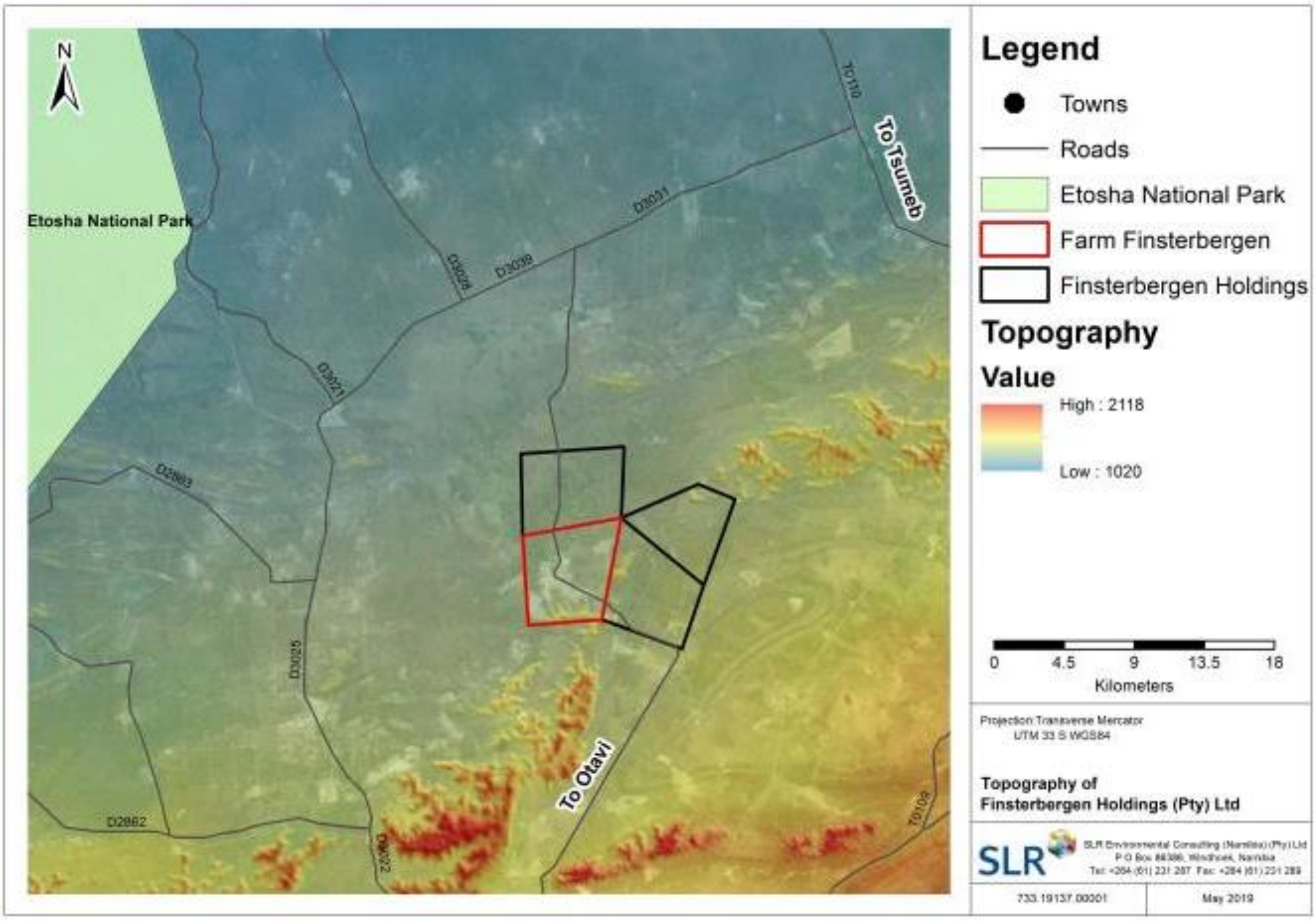



**FIGURE 2-1: TOPOGRAPHY OF THE LARGER AREA SURROUNDING FINSTERBERGEN HOLDINGS**

## 2.2 CLIMATE

### 2.2.1 Rainfall

Aquifer recharge resulting from rainfall events is dependent on the temporal and spatial variation in precipitation as well as the host rock surface and subsurface susceptibility in terms of infiltration and storage. By virtue of its surface and subsurface hydrogeological conditions, the dolomite outcrops are potentially a good recharge area. Due to the fact that most of the precipitation in the region is in the form of thunderstorms, it is likely that some of the rain water infiltrates into open fractures and faults to finally reach the groundwater table before evaporating or flowing overland into the next drainage line. Indirect recharge due to flood events in ephemeral rivers is assumed to be of minor importance in the project area. Figure 2-2 presents the average annual rainfall specific to Farm Finsterbergen's location.

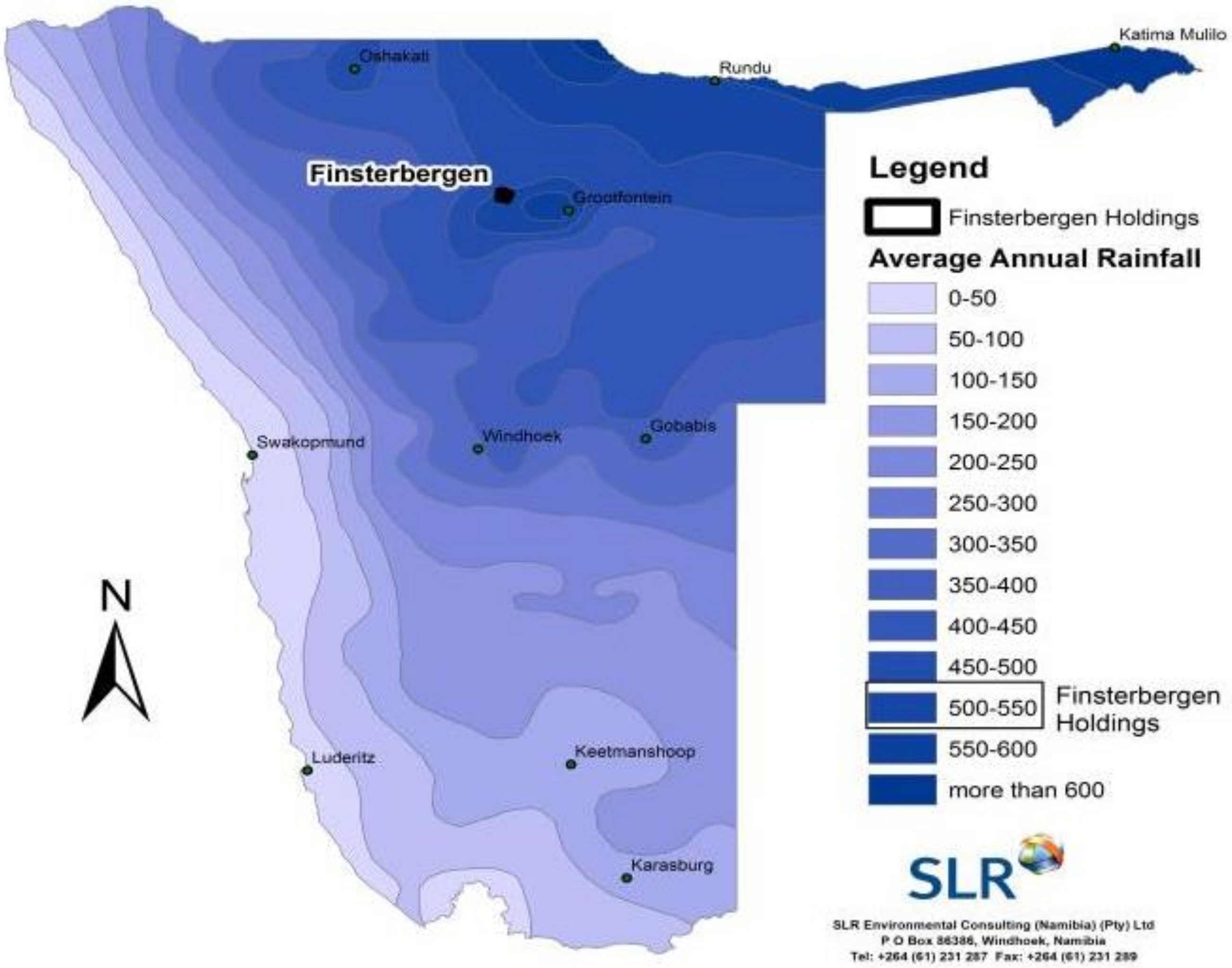



**FIGURE 2-2: AVERAGE ANNUAL RAINFALL FOR NAMIBIA**

### 2.2.2 Evaporation

The following evaporation data was taken from the Department of Water Affairs Evaporation Map Report (1988), calculated from Met. Office Class - A evaporation pan data. The nearest indicator site in this report was Tsumeb, which is 40 km due north east of the proposed site. The evaporation values for Tsumeb were then converted to open water values (evaporation from a Class - A evaporation pan is higher than from an open body of water) to compile an estimated evaporation distribution for the Tsumeb area. The estimated open water evaporation values are shown in Table 2-1and Figure 2-3.

**TABLE 2-1: TSUMEB AREA MONTHLY RAINFALL AND EVAPORATION**

| Tsumeb Mean Annual Evaporation | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly Percentage | 11.9 | 11.2 | 11.8 | 10.7 | 8.0 | 7.3 | 6.2 | 5.5 | 4.9 | 5.4 | 7.3 | 9.8 | 100 |
| A-Pan Evaporation (mm) | 249.2 | 234.5 | 247.1 | 224.1 | 167.5 | 152.9 | 129.8 | 115.2 | 102.6 | 113.1 | 152.9 | 205.2 | 2 094 |
| Open Water Evaporation (mm) | 174 | 164 | 173 | 179 | 134 | 122 | 104 | 92 | 82 | 90 | 122 | 164 | 1 602 |
| Tsumeb Mean Monthly Rain (mm) | 24.5 | 34.6 | 64.5 | 119.3 | 112.1 | 59.4 | 22.4 | 1.8 | 0.0 | 0.0 | 0.0 | 4.3 | 450.6 |

As can be seen from these figures the monthly evaporation for all months is higher than the rainfall, indicating that the Tsumeb area is a water negative area, meaning that there is an overall deficit in the available water, especially during the months from April to November, when there is little or no rainfall. However, from Figure 2-3 it can be seen that in January and February the mean monthly rainfall and evaporation are much closer, suggesting that the area becomes more of a water neutral area, where rainfall nearly matches evaporation.

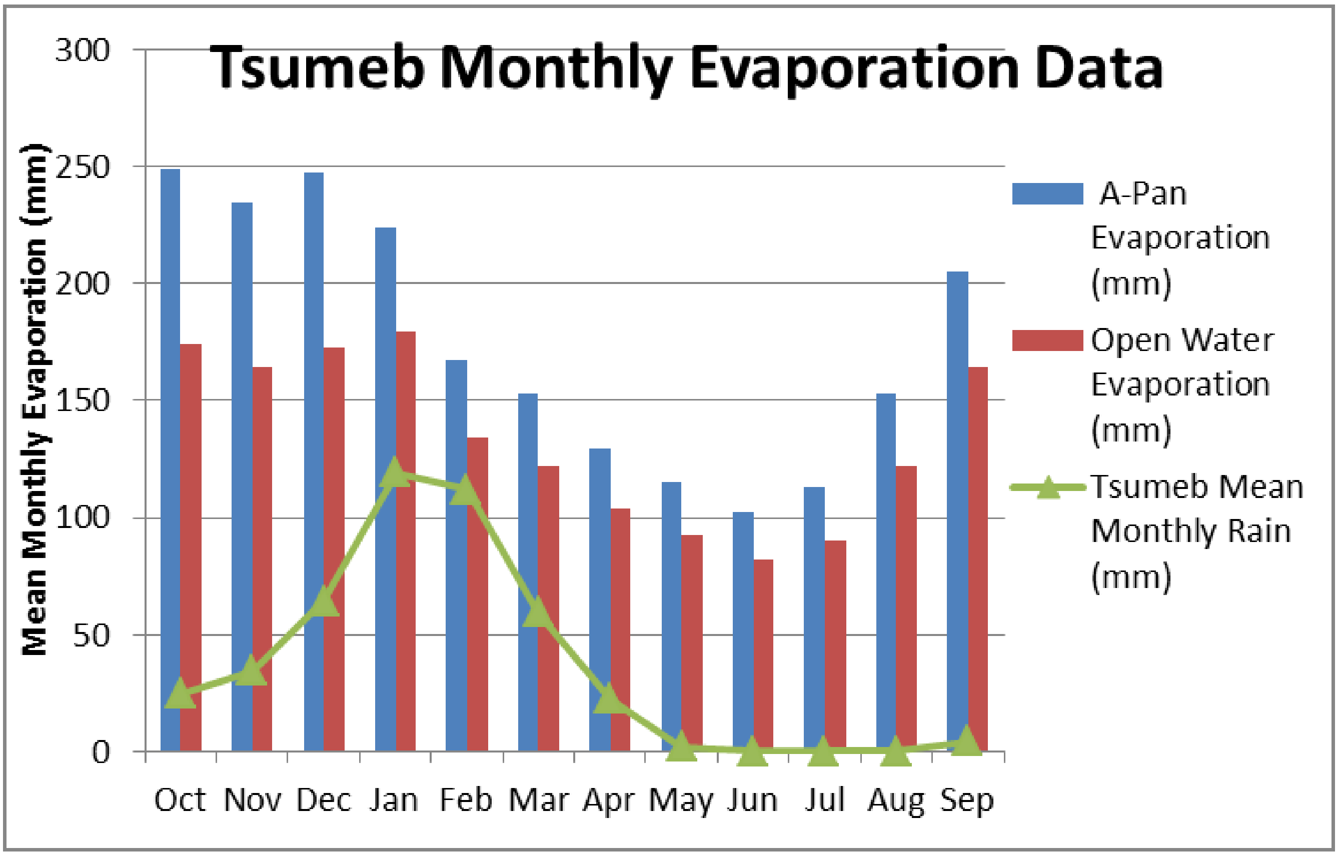



**FIGURE 2-3: MEAN MONTHLY EVAPORATION VS MONTHLY RAINFALL FOR TSUMEB AREA**

## 2.3 GEOLOGY

### 2.3.1 Regional Geology

The regional geology of the Otavi Mountain Lands (OML) was first documented by Söhnge (1957), who collated the results of regional mapping conducted by geologists of the Tsumeb Corporation Limited (TCL) and the South West Africa Company (SWACO). Subsequent studies of the OML were attempted by Grabler (1961), Hedberg (1979), Van der Westhuizen (1984), Misiewicz (1988) and Laukamp (2006) all of which used Söhnge's work as a basis.

Two phases of folding have been recognized in the OML. The first phase of folding (F1) was the most intense, and was the result of compressional forces from the north and south. This event commenced after the deposition of the Hüttenberg Formation, the uppermost unit of the Tsumeb Subgroup, and prior to and concurrently with the deposition of the Mulden Group. F1 folding is characterized by tight and in places overturned east-west trending folds. The carbonaceous/dolomitic portions of these synclines are known to be good aquifers in the OML.

The second phase of folding (F2) was initiated by mild east-west compression, resulting in the low-sinuosity re-folding of F1 synclines and anticlines. The F2 event was also accompanied by widespread jointing and fracturing, between 650 and 620 Ma. Figure 2-4 represents the effect of a fault in a fractured system on the groundwater characteristics in terms of transmissivity and permeability. Faults mapped in OML are considered as important groundwater conduits and will be assigned with higher transmissivities in the groundwater model.

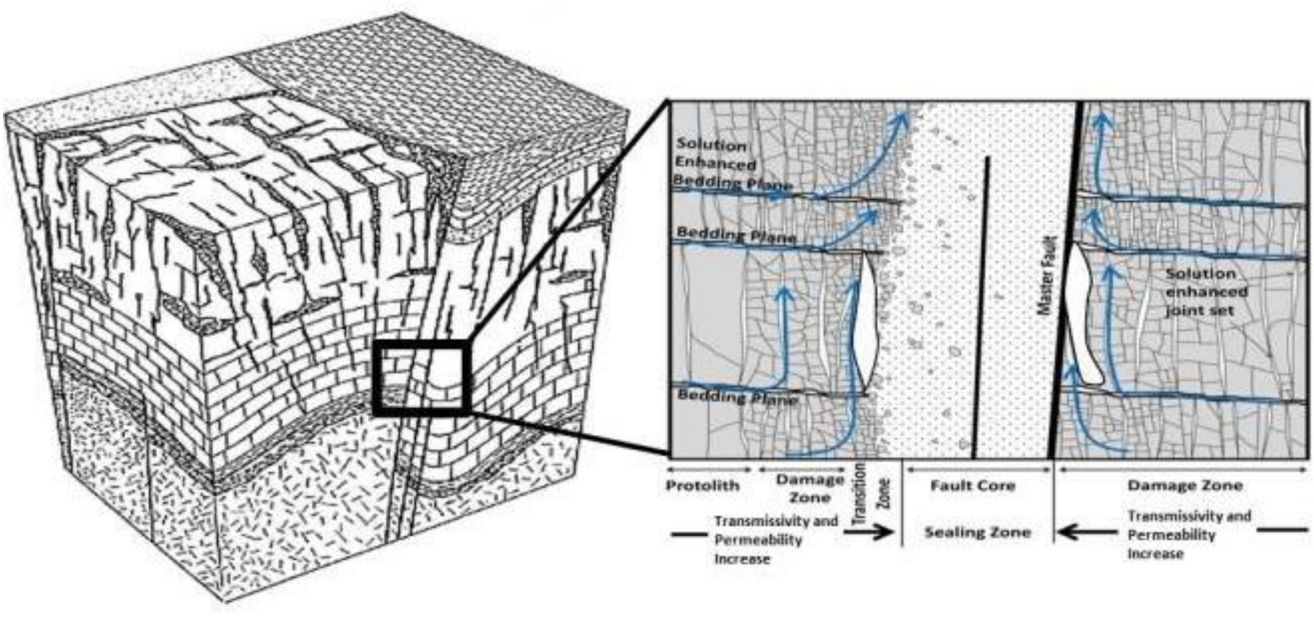



**FIGURE 2-4: EFFECT OF A FAULT IN A FRACTURED AQUIFER**

The OML is the best known portion of the Northern Platform due to its abundant mineral occurrences. Figure 2-5 represents a simplified geological map of the OML. The principal rock types exposed are carbonates of the Otavi Group, which were deposited on clastic and metavolcanic sequences of the Nosib Group, in addition to remnants of lower Proterozoic granite and gabbro, which form the basement complex. Basement lithologies are poorly exposed, but are known to be widely occurrent, based on exploration drill hole intersections. The meta-sediments of the Mulden Group unconformably overlie the Otavi Group.

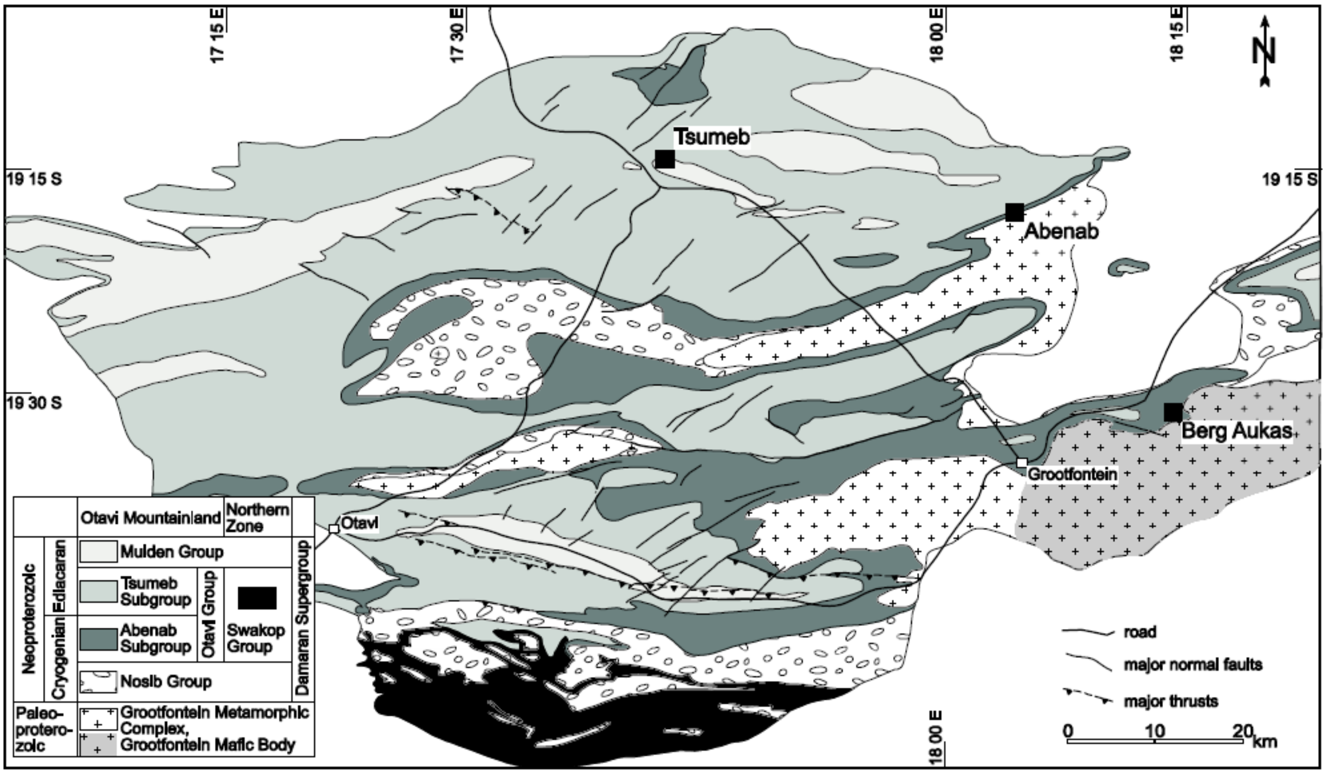



**FIGURE 2-5: GEOLOGY OF THE OML**

## 2.3.2 Local Geology

The study area is situated on the western edge of the Otavi Mountainland (OML). Figure 2-6 shows the geological situation of the investigation area with Quaternary cover.

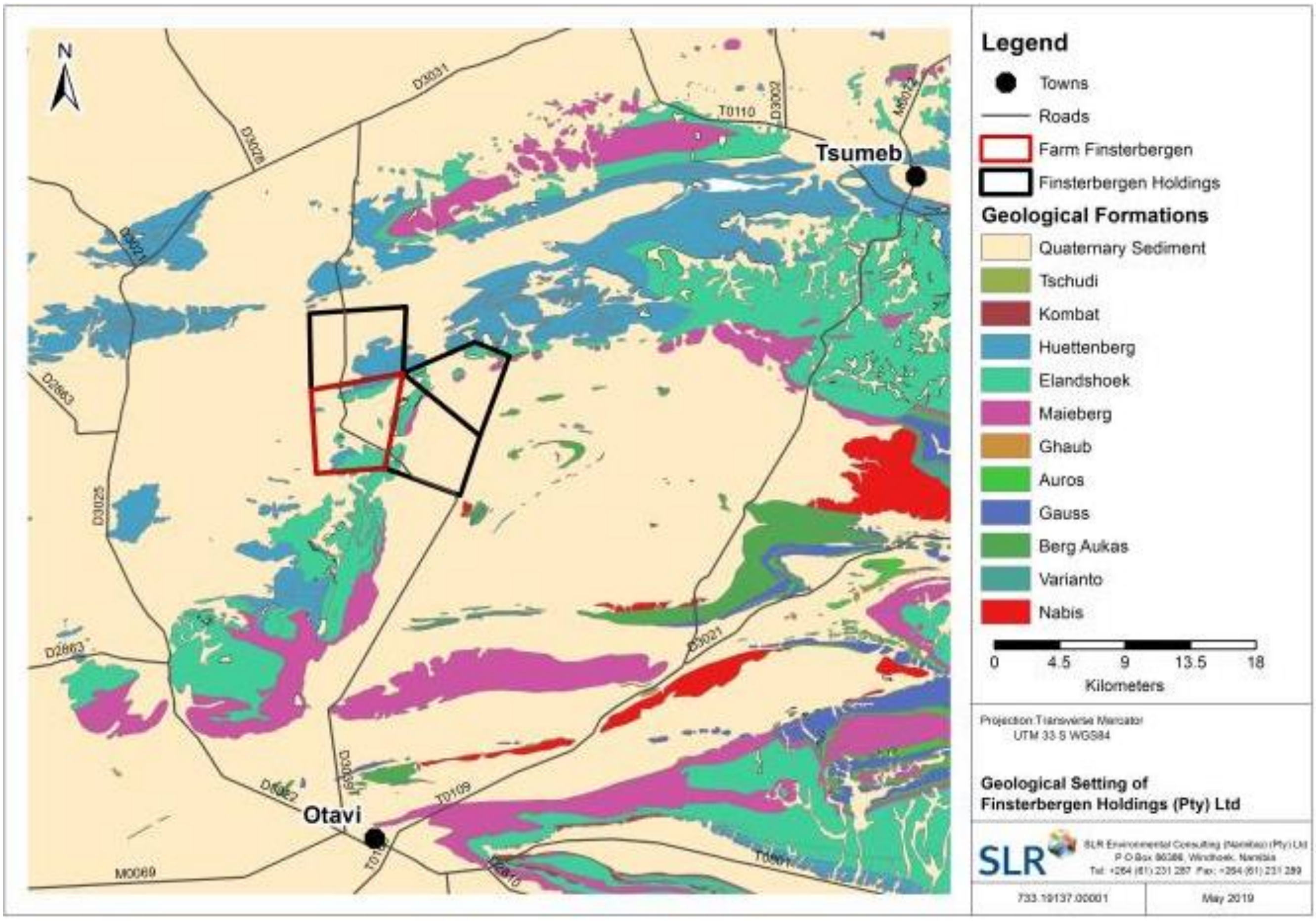



**FIGURE 2-6: GEOLOGICAL MAP**

## 2.4 GROUNDWATER

In hydrogeological terms, relevant groundwater flow is restricted to the dolomites of the Tsumeb Subgroup and minor to the other fractured but less permeable hard rocks. All geological formations acting either as aquifer, aquitard or aquiclude are summarised in stratigraphical order:

- **The Nosib Group** unconformably overlies the Basement Complex. It consists of the Nabis and Varianto formations. The environment of deposition progressively developed from predominantly fluvial to marine when finer grained shales were deposited. Aquifers of the Nosib Group are generally of moderate potential.

- **The Otavi Group** consists of Abenab and the Tsumeb Subgroups which are unconformably overlying the Nosib Group and the Basement Complex the Group's sediments form major aquifers in the area utilised for bulk water supply. The Tsumeb Subgroup, is subdivided into 8 litho-zones (T1 to T8) from the clastic Ghaub Formation to the carbonate dominant Maieberg, Elandshoek as well as the Hüttenberg Formations elaborated on below:

    - The Ghaub Formation, referred to as T1, is a glacio-marine tillite with lenses of dolomite and schist. The Maieberg Formation is a platform slope, deep water deposit and overlies the Ghaub Formation. The lower Maieberg Formation (T2) consists of slump brecciated and laminated carbonate and argillaceous sediments. The upper Maieberg Formation (T3) comprises bedded and finely laminated carbonates.

  - The Elandshoek Formation conformably overlies the Maieberg Formation. It covers most of the northern limb of the Otavi Valley north of Kombat Mine. The lower Elandshoek Formation (T4) comprises of massive dolomite and is responsible for the rugged geomorphologic terrain of the northern limb of the Otavi Valley. The brecciation is generally intensive and therefore T4 is regarded as an important aquifer. The upper Elandshoek Formation (T5) is fairly thin and not easily distinguishable from T4.

  - The Hüttenberg Formation marks the facies change from the deep sea environment observed in the Elandshoek Formation to shallow lagoon shelves. The high potential aquifer consists of a grey bedded basal dolomite, stromatolite rich (T6), overlain by two upper units, a massive dark and bedded dolomite with chert and phyllite (T7) and T8 is marked by pisolite and oolite.

- **The Mulden Group** is characterised by the Kombat Formation in the southern part of the OML, which consists of a siliciclastic molasses (poorly graded phyllite, arkose, argillite and siltstone) deposited syntectonically during the early stage of the Damara Orogeny, and the Tschudi Formation (Arkose and feldspathic sandstone) in the northern part of the OML, and is separated from the Tsumeb Subgroup by an angular disconformity.

- **Tertiary and Quaternary cover** is mainly composed by sediments of the Kalahari Supergroup form a thin cover in most areas around Tsumeb; it can be thicker to the north and northwest of the town. The Kalahari sediments are represented by calcrete deposits around Otavi and they are locally important shallow aquifers.

The site is located on the Hüttenberg and Elandshoek Formations, a fractured and locally karstified dolomitic aquifer, in an ESE-WNW sloping valley formed as part of a synclinal/anticlinal structure. The groundwater is expected to move along fractured tectonic structures like fold axes, pressure relief joints, faults or on lithological contact zones (Figure 2-6). The average natural groundwater levels in the area are at approximately 1 260 m amsl (20 m below ground level) with little seasonal fluctuation in the levels.

The natural groundwater flow in the area is in a northerly direction. The dolomite of the Hüttenberg Formation shows high transmissivity and it is estimated that water migrates at a rate of approximately 1.08 m/day or 360 m/annum, although secondary fracture flow in the area may result in localised acceleration of the groundwater flow rates. The high elevation areas are considered as recharge zone for the groundwater. Noteworthy, groundwater flow is predominantly happening within the Tsumeb Subgroup. The Kalahari aquifer is acting with its thin layered sand and calcrete as a perched water table.

## 2.5 HYDROCENSUS

### 2.5.1 Boreholes identified in the project area

A hydrocensus was carried out by SLR Namibia between the 11$^{th}$ and 13$^{th}$ of February 2019 on Farm Finsterbergen and neighbouring farms to determine the current use and water levels in the area (Table 2-2 and Figure 2-7). A total of 26 boreholes were identified, surveyed and sampled which are installed with either hand-, wind-, mono-, solar- or submersible electrical- pumps. Groundwater levels could be obtained at 23 of these boreholes.

### TABLE 2-2: HYDROCENSUS RESULTS

| Borehole ID | Farm Name | Latitude (Decimal degrees) | Longitude (Decimal degrees) | Elevation (m amsl) | RWL (m bgl) | Installation | Blow Yield ($m^3/h$) | Use |
|---|---|---|---|---|---|---|---|---|
| BH01 | Finsterbergen | -19.38912 | 17.34460 | 1275 | 16 | Electrical | 80 | None |
| BH02 | Finsterbergen | -19.38015 | 17.33233 | 1273 | | Electrical | 50 | None |
| BH03 | Finsterbergen | -19.38849 | 17.34341 | 1159 | 16.7 | Open | 100 | None |
| BH04 | Finsterbergen | -19.37988 | 17.33196 | 1272 | 14.1 | Open | 45 | None |
| BH05 | Finsterbergen | -19.38082 | 17.33169 | 1273 | 14.4 | Open | 60 | None |
| BH06 | Finsterbergen | -19.38165 | 17.33216 | 1273 | 14 | Open | 25 | None |
| BH07 | Finsterbergen | -19.37773 | 17.34038 | 1279 | 15.1 | Open | 120 | None |
| BH08 | Finsterbergen | -19.39475 | 17.33149 | 1281 | 17.5 | Open | 50 | None |
| BH09 | Finsterbergen | -19.39922 | 17.32217 | 1280 | 12.8 | Open | 40 | None |
| BH10 | Naomi | -19.39459 | 17.28320 | 1271 | 9.4 | Windmill | - | Livestock |
| BH11 | Naomi | -19.38428 | 17.31020 | 1268 | 9.5 | Electrical | - | Domestic |
| BH12 | Neuhorst | -19.41540 | 17.40258 | 1322 | | Solar (Pumping) | 15 | Domestic |
| BH13 | Neuhorst | -19.36673 | 17.37926 | 1282 | | Solar (Pumping) | 10 | Game |
| BH14 | Neuhorst | -19.39261 | 17.41032 | 1324 | 40.1 | Windmill | 12 | Game |
| BH15 | Neuhorst | -19.37863 | 17.39305 | 1300 | | Solar (Pumping) | 10 | Game |
| BH16 | Neuhorst | -19.41316 | 17.37424 | 1302 | | Windmill | 10 | Game |
| BH17 | Neuhorst Noord | -19.35028 | 17.43305 | 1294 | 69 | Open | - | None |
| BH18 | Neuhorst Noord | -19.37128 | 17.40483 | 1297 | 47.6 | Open | - | None |
| BH19 | Neuhorst Noord | -19.37113 | 17.40452 | 1302 | 58.5 | Open | - | None |
| BH20 | Rusoord | -19.32819 | 17.34219 | 1259 | | Engine | - | Game |
| BH21 | Rusoord | -19.34356 | 17.33916 | 1265 | 25.5 | Engine | - | Game |
| BH22 | Rusoord | -19.34412 | 17.33815 | 1263 | 14.9 | Open | - | None |
| BH23 | Rusoord | -19.35327 | 17.36142 | 1274 | 19.15 | Open | - | None |
| BH24 | Rusoord | -19.32865 | 17.37045 | 1265 | 27.2 | Open | - | None |
| BH25 | Thuringen | -19.42374 | 17.30574 | 1270 | 13.9 | Windmill | 20 | Livestock |
| BH26 | Thuringen | -19.41742 | 17.33574 | 1277 | 20 | Windmill | 25 | Livestock |

Groundwater levels were measured as rest water level (RWL) at the time. Borehole yields are generally medium to high varying from $5m^3/h$ to $150m^3/h$.

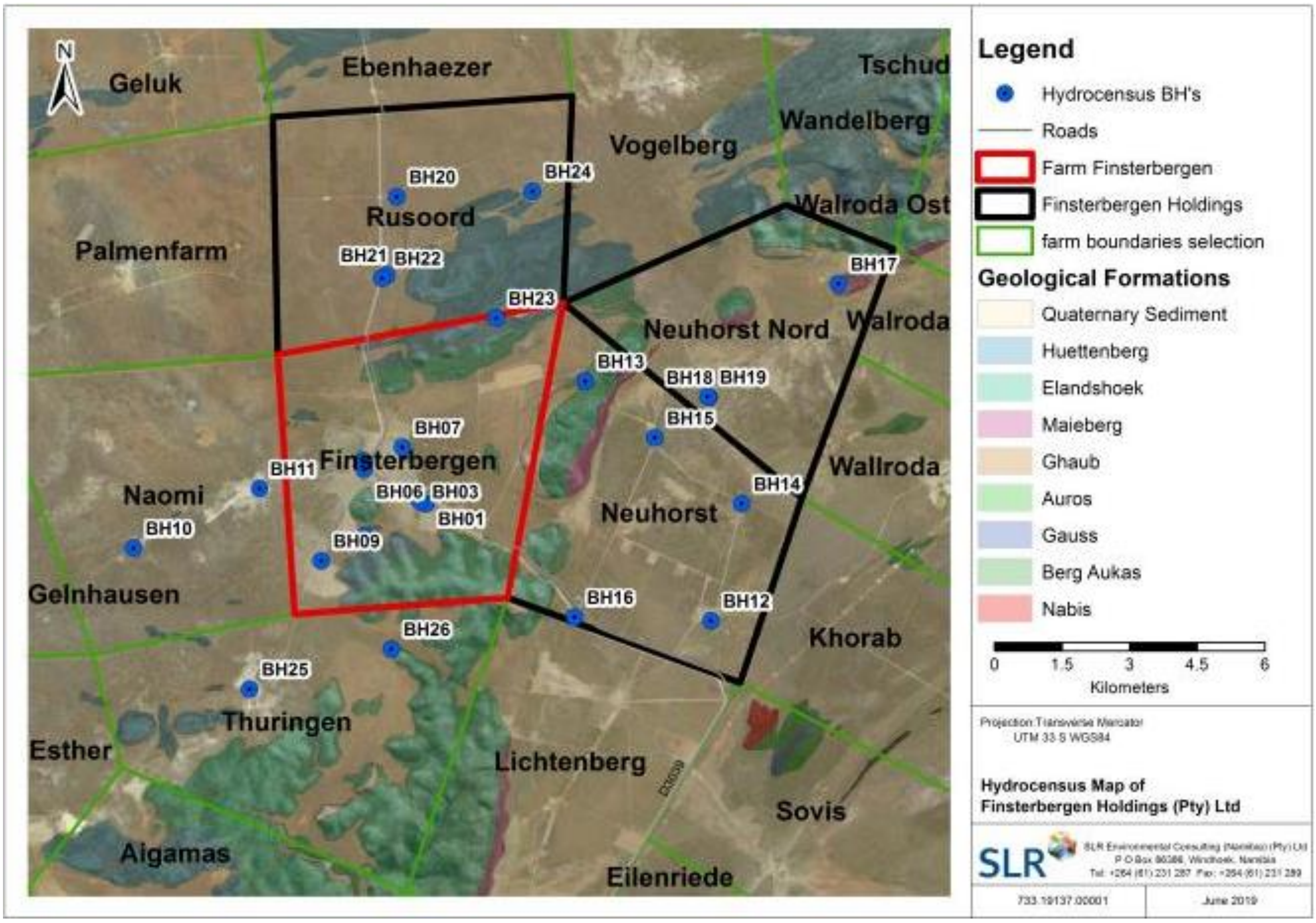



**FIGURE 2-7: HYDROCENSUS BOREHOLE LOCATIONS**

## 2.5.2 Groundwater quality and distribution of major ions

No water samples were taken during the hydrocensus and the water quality information discussed refers to the findings from the Tsumeb Groundwater Study (TGWS).

According to (SLR, 2019) the majority of analyses for major ions and physico-chemical parameters have indicated group A (excellent) and B (good) groundwater quality. Only five parameters (iron, nitrate, fluoride, sodium and electric conductivity) occasionally reveal a group D classification of the groundwater from the project area. The general assessment of the water quality were summarised as follows:

- The hydrochemical groundwater character in most of the study area is typical for an area dominated by carbonates. Both in the Dolomite Aquifer and in the Kalahari Aquifer, calcium, magnesium and bicarbonate dominate the solute content of the groundwater. Accordingly, high hardness of the groundwater is apparent.

- The high nitrate content with concentrations of up to 700 mg/l and up to 270 mg/l indicates potential overutilization of fertiliser and/or infiltrating water with faeces contamination from live stock.

- It is assumed that the fluoride concentrations, with maximum concentrations of 10 mg/l and 4.4 mg/l according to Phase 2 analyses (scattered throughout the study area), could be caused by the dissolution of occasionally occurring fluor-apatite, which can originate from the deposition of volcanic material eroded in the Otavi Mountainland (Nosib Group).

- Iron concentrations of group D are observed in seven analyses of the Phase 2 investigations, at the Abenab mine area and scattered elsewhere over the study area. The iron concentrations range from 2.2 mg/l to 13.3 mg/l. The elevated concentrations may originate from locally confined concentrations of iron-bearing minerals.

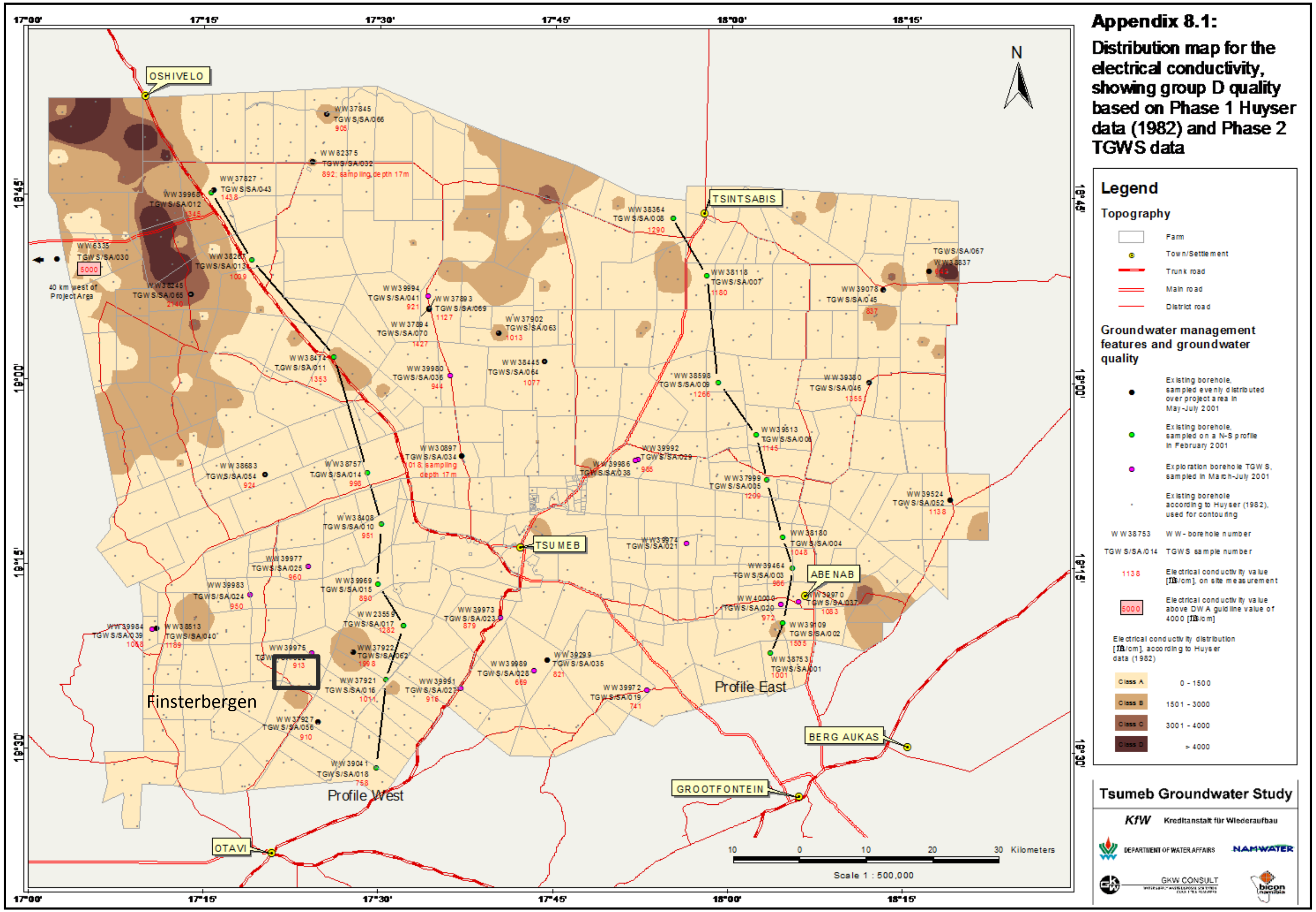
A distribution map of electrical conductivity in the wider area is shown in Figure 2-8.

Based on a hydrocensus undertaken in November 2012, (SLR 2019) around the Tsumeb area the water quality for the wider area can be summarised as follows:

- High calcium, magnesium, bicarbonate water is encountered as expected from dolomitic aquifer.

- pH values between 6.9 and 7.4 were measured in the hydrocensus boreholes. pH across boreholes is stable.

- Elevated iron (Fe) is also observed in all boreholes and is probably a result of the mineralogical composition of the rock.




## FIGURE 2-8: ELECTRICAL CONDUCTIVITY DISTRIBUTION MAP

## 2.6 AQUIFER RECHARGE

A large range of groundwater recharge rates have been reported by several investigations within Namibia and the study area itself. Values vary from 0.01% to 10% of mean annual rainfall, accordingly. Tsumeb has an annual average rainfall of 520 mm (between 500 and 550 mm in the area) with most of the rainfall occurring in the summer months (October to April). Approximately two thirds of the rainfall occurs in the months of January, February and March, with the highest number of productive rainfall days (i.e. days with rainfall of 10 mm and more) registered in January and February. Groundwater recharge is extremely variable in the area Table 2-3.

**TABLE 2-3: INITIAL GROUNDWATER RECHARGE VALUES (SLR, 2019)**

| Formation description | Type | Assigned recharge value |
|---|---|---|
| Dolomite covered by a thin layer of Kalahari calcrete or sand | Aquifer | Approximately 1% of the long-term average annual precipitation |
| Dolomite Outcrop Area | Aquifer | 10% of the mean annual precipitation in the higher elevated southern ranges and 6% of the mean annual precipitation towards the lower elevated central and eastern areas |
| Schist, mixtite and phyllite | Aquitard | Less than 0.1% of the annual precipitation |
| Basement sub outcrop areas | Aquiclude | 0.01% of the annual precipitation |

Dolomite outcrops are showing relatively high groundwater recharge, whereas basement sub outcrops are significantly lower. Wherever dolomite and/or other rock types are overlain by Kalahari calcrete or sandy layers, intermediate recharge values have been observed.

## 2.7 LAND USE

The majority of land surrounding Farm Finsterbergen is used for cattle rearing activities, although some dry land and irrigated crop production activities also take place. Neighbouring farming activities include cattle, game and goat farming.

# 3 LOCATION OF BOREHOLES AND INFRASTRUCTURE

Information provided in this section has been summarised in Appendix B with the relevant pictures taken of the visited borehole sites.

## 3.1 DESCRIPTION OF BOREHOLE'S LOCATION AND EXISTING INFREASTURCURE

### 3.1.1 Boreholes Sittings and location

In 2018, five (5) new boreholes identified as WW 205370 (BH1), WW 205368 (BH2), WW 205369 (BH3), WW 205367 (BH4), and WW 205371 (BH5) were sited and subsequently drilled on Farm Finsterbergen. Refer to Figure 1-2 for locality map to the boreholes. Based on the site visit undertaken on 18 April 2019, it was observed that the boreholes are not fully installed and don't include flow meters or dipper tube pipes for monitoring purposes. The boreholes locations are in areas that are relatively far operational activities on the farm that could be considered as a risk to groundwater pollution. The borehole infrastructure is similar and is further described below.

### 3.1.2 WW 205370 (BH1)

Borehole BH1 has been recently drilled. The borehole infrastructure includes a steel casing sticking out of the ground (refer to Appendix B for pictures to the borehole site). A borehole cap has not been installed and a heavy rock is placed over the open hole to prevent vandalism. There is no pump, electrical supply or piping. The surrounding existing infrastructure in the area is a reservoir currently that is currently empty and it is planned to be used for the pivot system. The borehole is accessible, via farm road. An electric fence up to 2.4 m high is planned to be installed once the construction and installation of pivot points are in progress. The borehole is planned to irrigate about 15 ha of land.

### 3.1.3 WW 205368 (BH2)

Similar to BH1, The borehole has been recently drilled and has a stick up casing/stand pipe/ steel casing sticking out of the ground. The borehole has not been installed. A heavy rock is also placed over the open hole to prevent vandalism. The existing infrastructure in the borehole's vicinity is the old farm house (refer to Appendix B for pictures to the borehole site). The borehole is accessible, via farm road. An electric fence up to 2.4 m high is also planned to be installed once the construction and installation of pivot points are in progress. This borehole is planned to be used for the irrigation of grass (Blue buffel).

### 3.1.4 WW 205369 (BH3)

Similar to BH1 and BH2, BH3 has been recently drilled. The borehole has a stick up casing/stand pipe/ steel casing sticking out of the ground and has not been installed. A heavy rock is also placed over the open hole to prevent vandalism. The existing infrastructure in the vicinity is the farm house and old steel wire and pipes abandoned around 5-10 m radius of the borehole. The borehole is accessible, via farm road and potential vandalism exists from monkeys currently, however, a 2.4 m high electric fence is also planned once the construction and installation of pivot points are in progress.

### 3.1.1 WW 205367 (BH4)

Similar to BH1 to BH3, BH4 has also been recently drilled into the area. The Borehole has a stick up casing/stand pipe/ steel casing sticking out of the ground. It has not been installed. A heavy rock is placed over the open hole to prevent vandalism. The borehole is far from any existing infrastructure and only trees surrounded by the background trees. The borehole is accessible, via farm road and potential vandalism exists from Wildlife including monkeys. However, an electric fence is planned once the construction and installation of pivot points are in progress for the final phase.

#### 3.1.2 WW 205371 (BH5)

Similar to BH1 to BH4, BH5 was recently drilled into the area. BH5 has a stick up casing/stand pipe/ steel casing sticking out of the ground and has not been installed. A heavy rock is placed over the open hole to prevent vandalism. The existing infrastructure in the vicinity is other old existing boreholes used for the previous irrigation scheme. The existing old boreholes are installed with pipelines and electrical cabling. The borehole is accessible, via farm road and potential vandalism exists from monkeys currently. However, an electric fence is planned once the construction and installation of pivot points are in progress. It is planned to be used for the irrigation of the plot north east of this borehole.

# 4 WATER MONITORING ACTIVITIES

## 4.1 GROUNDWATER ABSTRACTION

Farm Finsterbergen has not undertaken irrigation activities for the past three years, no abstraction volumes have been measured. Furthermore, the boreholes (BH1-BH5) described above which are intended for the irrigation have not been installed for abstraction activities, and subsequently no flow meters are installed to measure any volume.

## 4.2 WATER QUALITY ANALYSIS

Water quality analysis for the current five boreholes on Farm Finsterbergen has not been undertaken.

# 5 GROUNDWATER MONITORING RESULTS

## 5.1 GROUND WATER ABSTRACTION AND LEVEL

There are currently no records on groundwater abstraction rates available due to no irrigation activities undertaken.

## 5.2 GROUND WATER QUALITY ANALYSIS

There are no further data to establish a water quality trend.

# 6 ENVIRONMENTAL IMPACT ASSESSMENT

This chapter presents the assessment of the potential impacts of groundwater abstraction activities on Farm Finsterbergen and the proposed increase in abstraction rate from the current 100 000 $m^3$ to 843,480 $m^3$/a per year.

## 6.1 INTRODUCTION

Marabu Trading has proposed an increase in ground water abstraction on farm Finsterbergen from the current permitted 100 000 $m^3$ to 843 480 $m^3$ per annum. The proposed increase will be required for irrigation purposes. Over the past three years, no irrigation activities took place on farm Finsterbergen, the new development will be conducted on existing cleared land (150 ha) used for irrigation by the previous owner. It must be taken into consideration that the permited 5 new boreholes were drilled in the same area of previous irrigation scheme with an annual abstraction permit of 100 000 $m^3$ per annum.

SLR undertook a Groundwater Assessment Study in September 2019 (Appendix B) to investigate the impacts of the proposed increased groundwater abstraction rates on the groundwater resource and other users i.e. Rusoord, Neuhorts and Neuhorst Nord. SLR developed a numerical groundwater model to predict the likely drawn down in ground water level as a result of the increased abstraction.

The model scenarios were formulated to assess the impact of abstraction on surrounding water levels. The model was calibrated in steady state and then converted to transient flow for scenarios to predict changes in water levels over time more accurately.

There are several constraints on the model imposed by data limitations. The data constraints have significant implications for model certainty and the level of confidence in results. The Finsterbergen groundwater flow model can be described as a model of medium complexity with a high level of uncertainty especially outside of the focus area (supply scheme) and with respect to the underground geology.

Two abstraction scenarios were considered by simulating the long term pumping from boreholes WW205367-WW205371 for irrigation purposes. The predicted zone of influence or radius of influence is rated as medium in size and extends in a north westerly direction around the production boreholes. The assessment looks at possible negative impacts of groundwater users in the area.

The two scenarios are summarised below:

- Scenario 1: Annual groundwater recharge calculated from historic rainfall events which took place, for a periods of 5 years with an abstraction rate of 650 000 m3/a;
- Scenario 2: Annual groundwater recharge calculated from historic rainfall events which took place, for a periods of 5 years with an abstraction rate of 800 000 m3/a (optimum use on irrigated land).

Figure 6-1 presents the zone of influence (cone of drawdown) for abstracting 650 000 $m^3$/a for average annual recharge events. Due to high transmissivities of the Huttenberg formation the zone of influence stretches to about 26.9 $km^2$ when abstracting 650 000 $m^3$/a. Although the predicted zone of influence is large the total drawdown of the area is estimated at a maximum of 1.5 m at production boreholes and 1 m from initial conditions at the immediate surroundings.

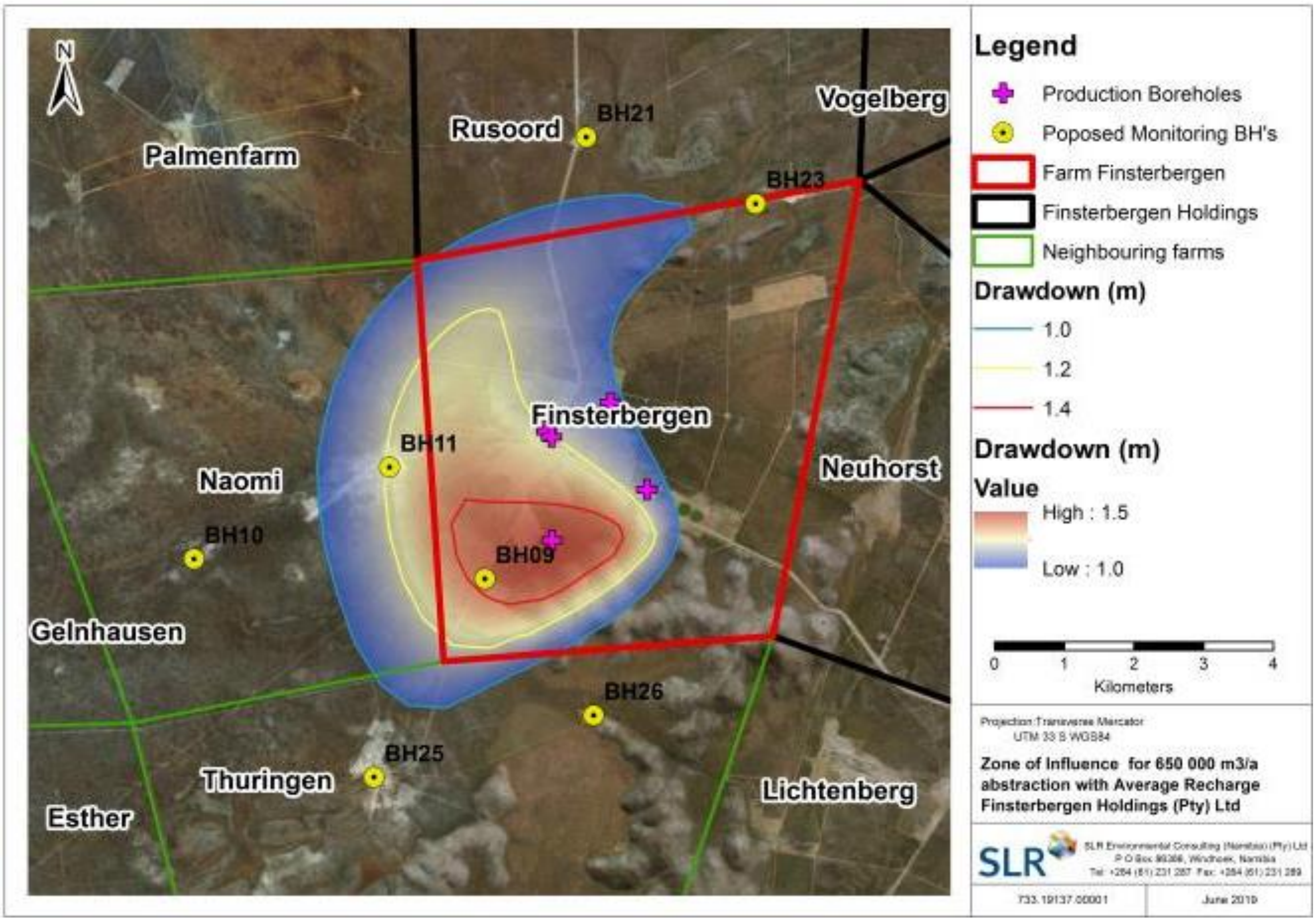



**FIGURE 6-1: ABSTRACTION OF 650 000 M3/A FOR A PERIOD OF 5 YEARS**

Figure 6-2 presents the zone of influence (cone of drawdown) for abstracting 800 000 $m^3$/a for average annual recharge events. Due to high transmissivities of the Huttenberg formation the zone of influence stretches to about 46.3 $km^2$ when abstracting 800 000 $m^3$/a. Although the predicted zone of influence is large the total drawdown of the area is estimated at a maximum of 1.8 m at production boreholes and 1 m from initial conditions at the immediate surroundings.

These results summarise normal conditions with average recharge contributing to the available water volume. Abstracting 800 000 $m^3$/a is preferred as this will allow the farmer to get optimum results for the irrigation scheme and food production.

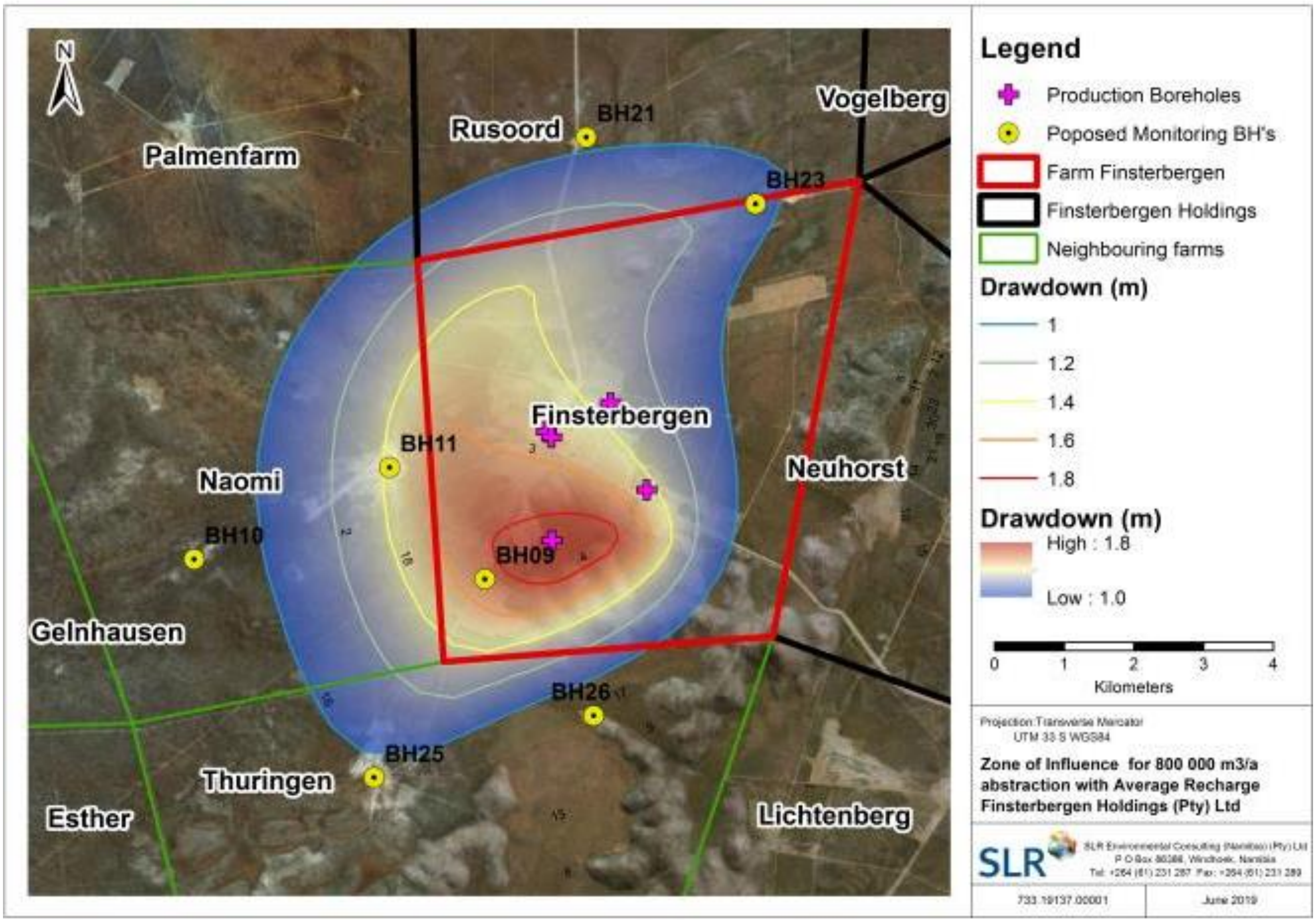



**FIGURE 6-2: ABSTRACTION OF 800 000 M³/A FOR A PERIOD OF 5 YEARS**

## 6.1 METHODOLOGY

### THE CRITERIA USED TO ASSESS THE IMPACTS AND THE METHOD OF DETERMINING THE SIGNIFICANCE OF THE IMPACTS IS OUTLINED IN

Table 6-1.This method complies with the Environmental Impact Assessment Regulations (Government Gazette No. 4878).

Part A provides the approach for determining impact consequence (combining severity, spatial scale and duration) and impact significance (the overall rating of the impact). Impact consequence and significance are determined from Part B and C. The interpretation of the impact significance is given in Part D. Both mitigated and unmitigated scenarios are considered for each impact.

The management and mitigation measures to address the identified impacts are included in the EMP in Section 7.

## TABLE 6-1: CRITERIA FOR ASSESSING IMPACTS

*Note: Both the criteria used to assess the impacts and the methods of determining the significance of the impacts are outlined in the following table. Part A provides the definition for determining impact consequence (combining severity, spatial scale and duration) and impact significance (the overall rating of the impact). Impact consequence and significance are determined from Part B and C. The interpretation of the impact significance is given in Part D.*

| **PART A: DEFINITION AND CRITERIA*** | | |
|---|---|---|
| **Definition of SIGNIFICANCE** | | **Significance = consequence x probability** |
| **Definition of CONSEQUENCE** | | **Consequence is a function of severity, spatial extent and duration** |
| **Criteria for ranking of the SEVERITY/NATURE of environmental impacts** | **H** | Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action. Irreplaceable loss of resources. |
| | **M** | Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints. Noticeable loss of resources. |
| | **L** | Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. Limited loss of resources. |
| | **L+** | Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. |
| | **M+** | Moderate improvement. Will be within or better than the recommended level. No observed reaction. |
| | **H+** | Substantial improvement. Will be within or better than the recommended level. Favourable publicity. |
| **Criteria for ranking the DURATION of impacts** | **L** | Quickly reversible. Less than the project life. Short term |
| | **M** | Reversible over time. Life of the project. Medium term |
| | **H** | Permanent. Beyond closure. Long term. |
| **Criteria for ranking the SPATIAL SCALE of impacts** | **L** | Localised - Within the site boundary. |
| | **M** | Fairly widespread – Beyond the site boundary. Local |
| | **H** | Widespread – Far beyond site boundary. Regional/ national |

| **PART B: DETERMINING CONSEQUENCE** | | | | | |
|---|---|---|---|---|---|
| | | | **SEVERITY = L** | | |
| **DURATION** | Long term | **H** | **Medium** | **Medium** | **Medium** |
| | Medium term | **M** | **Low** | **Low** | **Medium** |
| | Short term | **L** | **Low** | **Low** | **Medium** |
| | | | **SEVERITY = M** | | |
| **DURATION** | Long term | **H** | **Medium** | **High** | **High** |
| | Medium term | **M** | **Medium** | **Medium** | **High** |
| | Short term | **L** | **Low** | **Medium** | **Medium** |
| | | | **SEVERITY = H** | | |
| **DURATION** | Long term | **H** | **High** | **High** | **High** |
| | Medium term | **M** | **Medium** | **Medium** | **High** |
| | Short term | **L** | **Medium** | **Medium** | **High** |
| | | | **L** | **M** | **H** |
| | | | Localised<br>Within site boundary<br>Site | Fairly widespread<br>Beyond site boundary<br>Local | Widespread<br>Far beyond site boundary<br>Regional/ national |
| | | | **SPATIAL SCALE** | | |
| **PART C: DETERMINING SIGNIFICANCE** | | | | | |
| **PROBABILITY (of exposure to impacts)** | Definite/ Continuous | **H** | **Medium** | **Medium** | **High** |
| | Possible/ frequent | **M** | **Medium** | **Medium** | **High** |
| | Unlikely/ seldom | **L** | **Low** | **Low** | **Medium** |

| | | | | | |
|---|---|---|---|---|---|
| | | | L | M | H |
| | | | CONSEQUENCE | | |

| | |
|---|---|
| **PART D: INTERPRETATION OF SIGNIFICANCE** | |
| **Significance** | **Decision guideline** |
| High | It would influence the decision regardless of any possible mitigation. |
| Medium | It should have an influence on the decision unless it is mitigated. |
| Low | It will not have an influence on the decision. |

***H = high, M= medium and L= low and + denotes a positive impact.**

## 6.2 ASSESSMENT OF IMPACTS

### 6.2.1 Issue: The overuse of pesticides, herbicides, fertilizers and the accidental spill of hydrocarbons impacting on groundwater quality and water supply to other users

#### Introduction

Spillages of hazardous chemicals (e.g. hydrocarbons, fertiliser, pesticides etc) or the overuse of fertiliser and pesticides during agricultural activities contaminate soils and surface water. This contamination could travel to groundwater (rapidly down the boreholes or more slowly through recharge) and cause contamination of groundwater. If the contamination event was substantial or frequent it could alter groundwater quality, this could impact on the suitability of water for use by Farm Finsterbergen and other users/the neighbouring community.

Boreholes BH1 - BH5 are not in close proximity to storage facilities that could result in hydrocarbon or chemical spillages and therefore pollution of the groundwater. The likelihood of hydrocarbon incidents happening in proximity to the boreholes from operational vehicles/ equipment is low. Currently BH1 - BH5 are not installed and will be fitted with electric pumps, therefore operational and maintenance activities that could subsequently result in hydrocarbon spillages are unlikely. No evidence of any spillages or soil contamination by hydrocarbons was observed at any of the borehole sites. There is a potential risk leading to pollution from the over-use of pesticides and herbicides a groundwater monitoring programme is recommended, and additional mitigation measures is recommended (Refer to Section 7).

#### Assessment of impact

**Severity:**

Once hydrocarbons, fertilizers or pesticides have entered the hydrological cycle, their elimination is difficult, and in most places impossible, especially so with groundwater. Many of the components of hydrocarbons, fertilizers or pesticides are toxic and their presence in groundwater could have deleterious effects for groundwater users. The severity of the impact is high in unmitigated cases, whereby recommended concentrations will often be violated and low in mitigated scenario.

**Spatial Scale:**

The impact would extend beyond the site boundary as contamination transport is expected to be widespread, though local, following the groundwater flow patterns, hence medium influence in both the unmitigated and mitigated cases.

**Duration:**

The duration of pollution from irrigation is longer than the operations and also it is continuous, to the point where recycling of the pollution may occur, so the impact duration is high in the unmitigated and when the GPA guidelines are used, limited pollution will occur and thereby in the mitigated scenarios the impact will be medium.

**Consequence:**

In the unmitigated scenario, the consequence of the potential impact is medium and this reduces to low with mitigation.

**Probability:**

Probability of occurrence is high in the unmitigated case and low in the mitigated case.

**Significance:**

The significance of this potential impact is medium in the unmitigated scenario and low for the mitigated scenario. Refer to Section 9 (EMP) for the management and mitigation measures.

**TABLE 6-2: TABULATED SUMMARY OF THE ASSESSED IMPACT - THE OVERUSE OF PESTICIDES, HERBICIDES, FERTILIZERS AND THE ACCIDENTAL SPILL OF HYDROCARBONS IMPACT ON GROUNDWATER QUALITY AND WATER SUPPLY TO OTHER USERS**

| Mitigation | Severity | Duration | Spatial Scale | Consequence | Probability of occurrence | Significance |
|---|---|---|---|---|---|---|
| Unmitigated | H | H | M | M | H | M |
| Mitigated | L | M | M | L | L | L |

### 6.2.2 Issue: Increased abstraction of groundwater for irrigation purposes resulting in the lowering of the water table and reduced supply to neighboring farmers

#### Introduction

Over-abstraction of the groundwater above sustainable recharge rates/permitted thresholds has the potential to lower the groundwater table. If abstraction is persistently above the aquifer's recharge capability, this could impact on access to groundwater for Farm Finsterbergen and the supply to other users/the neighbouring community. The proposed increase in abstraction from boreholes on Farm finsterbergen could put the Aquifer under pressure if abstraction rates were above the aquifer's recharge capability.

In 2018 SLR developed an FEFLOW groundwater flow model for farm Cadix in the Abenab area, west of Tsumeb to predict the effects of groundwater abstraction on the surrounding aquifer. The model was done with the purpose of developing a management tool for sustainable groundwater abstraction for an irrigation scheme. Farm Cadix overlies the same hydrogeological units and therefore has been used the groundwater assessment study as a point of reference to develop the new FEFLOW-model for farm Finsterbergen. (Refer to Section 6.1 for additional reference to the model limitations)

The numerical groundwater flow model (FEFLOW) for farm Finsterbergen (SLR 2019) was calibrated using groundwater recharge rates, groundwater levels from boreholes and available information on aquifer characteristics, by fitting simulated groundwater levels in monitoring and production boreholes to observed ones. The model was developed using site specific data: piezometric surface and hydraulic gradient, hydraulic conductivity, storativity and recharge from previous model solutions and evaluation of pumping data of production boreholes and in surrounding areas.

A steady state solution was calculated to provide the initial conditions of a subsequent transient model using water level information from production and monitoring boreholes. A good reproduction of the observed water table was achieved for steady state calibration. The predicted zone of influence or radius of influence is relatively small and have a local groundwater impact mostly contained on the two farms. The assessment looks at possible negative impacts of groundwater users in the area.

As a result of the simulated groundwater flow as a steady-state solution, the following conclusions can be drawn and recommendations given:

- The calibrated groundwater flow depicts water level records measured during a hydrocensus and therefore presents real time data. The calibration is in an acceptable range, although other data (borehole logs etc.) were not available and therefore the confidence of this model is medium;
- Groundwater abstraction at a rate of 650 000 m3/a to a maximum of 800 000 m3/a from production boreholes has a limited and medium effect on groundwater levels with a maximum additional drawdown of 1.8 m deep in production boreholes and a zone of influence less than 45 km2 in diameter; and
- Groundwater abstraction will only have a small measurable effect on the regional groundwater levels and no significant negative impact on water supply of the neighbouring farmers.

The following sections assess the significance of impact related to the proposed increase in abstraction.

## Assessment of impact

**Severity:**

When groundwater is exploited, water levels will decline and continue to do so until they either stabilize at a lower level or, if abstraction is persistently greater than recharge, the aquifer is dewatered. The study area is located in the Water Controlled Area (WCA), where abstraction permits are required from the DWAF and where it is unlawful to allocate abstraction permits without proof from the applicant that the abstraction rates are sustainable. The Groundwater Assessment Study (Appendix A) indicated that the cumulative increase in groundwater abstraction on Farm Finsterbergen will have less measurable effect on the regional groundwater levels and no negative impact on water supply of the neighbouring farmers. The severity is rated as medium in unmitigated and low in mitigated scenarios.

**Spatial Scale:**

The abstraction of water for irrigation is predicted to have a radius of influence that can reach slightly into neighbouring farmers, therefore medium in unmitigated scenario and low in a mitigated scenario.

**Duration:**

Any effect of over abstraction is reversible and could revert back to natural conditions once pumping stops for prolonged periods and efficient time is given for aquifer recharge. Therefore can be rated Medium in unmitigated scenario and low in the mitigated.

**Consequence:**

In the unmitigated scenario, the consequence of the potential impact is medium as neighbouring land owners could be affected. This reduces to low with mitigation.

**Probability:**

Probability of occurrence is medium in the unmitigated case and low in the mitigated case.

**Significance**:

The significance of this potential impact is medium in the unmitigated scenario and low for the mitigated scenario. Refer to Section 7 (EMP) for the management and mitigation measures.

### TABLE 6-3: TABULATED SUMMARY OF THE ASSESSED IMPACT – THE PROPOSED INCREASE IN GROUNDWATER ABSTRACTION

| Mitigation | Severity | Duration | Spatial Scale | Consequence | Probability of occurrence | Significance |
|---|---|---|---|---|---|---|
| Unmitigated | M | M | M | M | M | M |
| Mitigated | L | L | L | L | L | L |

# 7 ENVIRONMENTAL MANAGEMENT PLAN

## 7.1 AIMS

The aim of the Environmental Management Plan (EMP) is to detail the actions required to effectively implement mitigation and management measures. These actions are required to minimise negative impacts and enhance positive impacts associated with the activities.

The EMP gives the commitments, which form the environmental contract between Marabu Trading's Farm Finsterbergen and the Government of the Republic of Namibia; represented by the Ministry of Environment and Tourism (MET).

It is important to note that an EMP is a living document in that it will be updated and amended as new information (e.g. environmental data), policies, authority guidelines and technologies develop. The conceptual management measures proposed to mitigate the potential impacts are detailed in the action plans below.

This EMP is only relative to the groundwater Boreholes (BH1-BH5) infrastructure and associated activities.

## 7.2 ACTION PLANS TO ACHIEVE OBJECTIVES

Action plans to achieve the objectives are listed in tabular format together, separated by activities.  The action plans also includes the frequency for implementing the mitigation measures as well as identifying the responsible party.

## 7.3 ROLES AND RESPONSIBILITIES

The responsibility in effective implementation of this EMP is that of Marabu Trading departmental function directly dealing with Water monitoring activities.

## TABLE 7-1 : MITIGATION ACTIONS RELATED TO GROUNDWATER CONTAMINATION

| Activities / facilities | Potential Impact | Management and mitigation measures | Action plan | |
|---|---|---|---|---|
| | | | Frequency / target date | Responsible parties |
| Farming activity and associated infrastructure, particularly near to borehole sites. | Soil and groundwater contamination (Impact on suitability of groundwater for use on Farm Finsterbergen and for other users) | • Farm Finsterbergen is responsible to ensure that proper groundwater borehole infrastructure i.e. electric pumps fitted with abstraction reading meters and Dippers should be installed for all boreholes.<br>• Borehole sites should be kept absolutely clean and storage of waste around these areas should be avoided.<br>• Regular environmental awareness should be provided to staff and include potential risks associated with hydrocarbons, fertilizers and pesticides.<br>• Vehicles, machinery and equipment shall be kept in good working condition to ensure they do not leak oil/diesel.<br>• Vehicles and machinery will be serviced in designated servicing bays/ area, as far as possible from the borehole sites. However, in the event where machinery needs to be repaired/serviced close to the boreholes, all care shall be taken to prevent spillage of oil/diesel by performing the work on impermeable surfaces or proper placement of drip trays.<br>• All used parts from vehicles and machinery (which may include, but not limited to, oil filter, pipes, rags, cans) will be collected and removed from site and disposed of in an appropriate manner.<br>• All refueling of vehicles will take place on impermeable surfaces. | Daily | Finsterbergen |

| Activities / facilities | Potential Impact | Management and mitigation measures | Action plan | |
|---|---|---|---|---|
| | | | Frequency / target date | Responsible parties |
| | | • Bulk storage of fuels or chemicals will be undertaken in appropriate facilities which prevent direct contact with soil and rainfall, and contain the material in the event of a spillage.<br>• Any spills will be contained and cleaned up immediately<br>• Spill kits will be readily available on site. Employees will be shown how to use the spill kits to enable containment and remediation of pollution incidents.<br>• Select chemicals with low toxicity outside target groups (i.e. highly specific), short half-lives and high levels of adsorption (this will reduce leaching problems);<br>• Use of optimal, not maximal doses;<br>• Application for as short periods as possible and selecting days that are not windy; and<br>• Ensuring that there is no overspray that drifts into the adjacent indigenous habitats or into areas of human habitation.<br>• Chemicals will be applied through the irrigation system, and using an optimal water management approach based on measured soil moisture levels will also mean that leaching will be limited.<br>• Take water samples from production and monitoring boreholes on regular basis (annually) and analyse for pesticides/herbicides/fertilisers and general water quality (major ions).<br>• Ensure all borehole cases and dipper holes are capped and locked. | | |

| Activities / facilities | Potential Impact | Management and mitigation measures | Action plan | |
|---|---|---|---|---|
| | | | Frequency / target date | Responsible parties |
| | | • Have proper storage of pesticides, and herbicide chemicals and fertilisers on site.<br>• Access to work in the area where boreholes are present should be obtained from the responsible parties managing the boreholes. | | |

## FIGURE 7-1: MITIGATION ACTIONS RELATED TO GROUNDWATER ABSTRACTION.

| Activities / facilities | Potential Impact | Management and mitigation measures | Action plan | |
|---|---|---|---|---|
| | | | Frequency / target date | Responsible parties |
| Groundwater abstraction including Increase in groundwater abstraction from 100 000 $m^3$ to 843,480 $m^3$/a for irrigation purposes. | Groundwater level | • Abstraction permits must be obtained from DWAF and conditions of the permit must be adhered to and documented.<br>• All water abstraction measures raised in the water permit should be adhered to.<br>• Regular inspection of water meters to ensure their functionality should be undertaken<br>• Maintain equipment to prevent leakages, meters on irrigation lines to monitor abstraction rates.<br>• Measure groundwater levels at monitoring borehole (BH09 - Mon, BH010 - Mon, BH011 - Mon, BH021 - Mon, BH023 - Mon and BH26 - Mon). Feedback from monitoring to change irrigation water application rates, should groundwater levels change significantly.<br>• Water meter installations should be as per Permit conditions.<br>• Water meter readings shall be undertaken on monthly basis and recorded on the prescribed Abstraction Return Form. | As per permit conditions | Finsterbergen |

| Activities / facilities | Potential Impact | Management and mitigation measures | Action plan | |
|---|---|---|---|---|
| | | | Frequency / target date | Responsible parties |
| | | • Water levels of the pumped source must be recorded once in every three months at the time before the pump is switched to allow for rest water levels recording.<br><br>• Shall permitted water levels be exceeded; this should be reported immediately to the regulating authority. | | |

# 8 MONITORING

Finsterbergen Holdings should establish a local groundwater monitoring network aiming at monitoring the cone of drawdown created by increased abstraction for irrigation purposes. It is recommended to monitor existing boreholes on farm Finsterbergen, Rusoord, Thuringen and Naomi. Monitoring includes measuring of groundwater levels on a monthly basis to determine if the cone of drawdown extends further than predicted by the model.

The location and number of monitoring boreholes are shown in Figure 8-1 below.

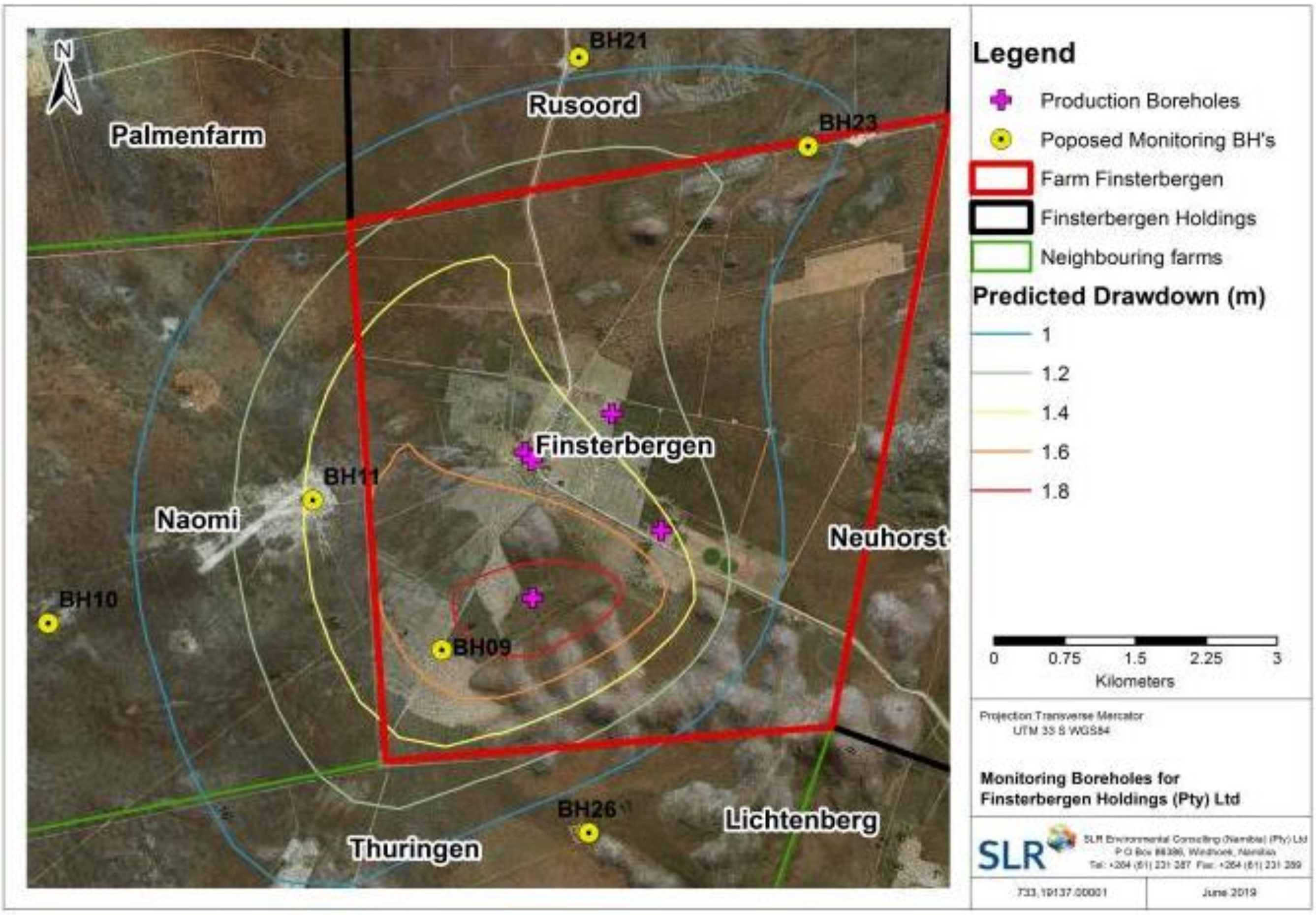



**FIGURE 8-1: EXISTING FARM BOREHOLES RECOMMENDED FOR MONITORING**

# 9 CONCLUSION

The Environmental Performance Report and Impact Assessment is based on findings observed during the site visit undertaken on 18th of April 2019 and the Groundwater Assessment Study undertaken to investigate the potential impacts of the proposed increase in groundwater abstraction. SLR is of the opinion that the proposed increase in groundwater abstraction from 100 000 $m^3$ to 843,480 $m^3$ per annum is feasible as concluded in the Groundwater Assessment Study. The management and mitigation measures relevant to the groundwater abstraction activity have been provided in the EMP in Section 7.

Provided that Farm finsterbergen continues to manage and monitor the water abstraction activities and implement the management and mitigation measures raised in this report, there is no reason why the MET should not issue the required ECC.

[Marvin Sanzila]

**Project Manager**

[Jonathan Crowther]

**Approved Reviewer**

# 10 REFERENCES

- SLR 2019. Groundwater Study for Farm Finsterbergen, Otavi Area, SLR Project No.: 733.19137.00001

## APPENDIX A: GROUNDWATER ASSESSMENT STUDY FOR FARM FINSTERBERGEN

## APPENDIX B: DESCRIPTION OF THE BOREHOLE'S SITE

| Production Borehole Identification | Picture | Description of the borehole and associated infrastructure. |
|---|---|---|
| WW 205370 (BH1) |  | Borehole BH1 has been recently drilled. The borehole infrastructure includes a stick up casing, stand pipe and a steel casing sticking out of the ground. The Borehole has not been installed. A heavy rock is placed over the open hole to prevent vandalism.<br><br>The surrounding existing infrastructure in the area is a reservoir currently that is currently empty and it is planned to be used for the pivot system.<br><br>The borehole is accessible, via farm road. An electric fence up to 2.4 m high is planned to be installed once the construction and installation of pivot points are in progress. The borehole is planned to irrigate about 15 ha of land. |

| Production Borehole Identification | Picture | Description of the borehole and associated infrastructure. |
|---|---|---|
| WW 205368 (BH2) |  | Similar to BH1, The borehole has been recently drilled and has a stick up casing/stand pipe/ steel casing sticking out of the ground. The borehole has not been installed.<br><br>A heavy rock is also placed over the open hole to prevent vandalism. The existing infrastructure in the borehole's vicinity is the old farm house.<br><br>The borehole is accessible, via farm road. An electric fence up to 2.4 m high is also planned to be installed once the construction and installation of pivot points are in progress. This borehole is planned to be used for the irrigation of grass (Blue buffel). |
| WW 205369 (BH3) |  | Similar to BH1 and BH2, BH3 has been recently drilled. The borehole has a stick up casing/stand pipe/ steel casing sticking out of the ground and has not been installed.<br><br>A heavy rock is also placed over the open hole to prevent vandalism. The existing infrastructure in the vicinity is the farm house and old steel wire and pipes abandoned around 5-10 m radius of the borehole.<br><br>The borehole is accessible, via farm road and potential vandalism exists from monkeys currently, however, a 2.4 m high electric fence is also planned once the construction and installation of pivot points are in progress. |

| Production Borehole Identification | Picture | Description of the borehole and associated infrastructure. |
|---|---|---|
| WW 205367 (BH4) |  | Similar to BH1 to BH3, BH4 has also been recently drilled into the area. The Borehole has a stick up casing/stand pipe/ steel casing sticking out of the ground. It has not been installed. A heavy rock is placed over the open hole to prevent vandalism.<br><br>The borehole is far from any existing infrastructure and only trees surrounded by the background trees. The borehole is accessible, via farm road and potential vandalism exists from Wildlife including monkeys.<br><br>However, an electric fence is planned once the construction and installation of pivot points are in progress for the final phase. |
| WW 205371 (BH5) |  | Similar to BH1 to BH4, BH5 was recently drilled into the area. BH5 has a stick up casing/stand pipe/ steel casing sticking out of the ground and has not been installed. A heavy rock is placed over the open hole to prevent vandalism.<br><br>The existing infrastructure in the vicinity is other old existing boreholes used for the previous irrigation scheme. The existing old boreholes are installed with pipelines and electrical cabling. The borehole is accessible, via farm road and potential vandalism exists from monkeys currently. However, an electric fence is planned once the construction and installation of pivot points are in progress. It is planned to be used for the irrigation of the plot north east of this borehole. |

| Production Borehole Identification | Picture | Description of the borehole and associated infrastructure. |
|---|---|---|
| | | |
| Boreholes around BH5 |    | Old Borehole infrastructure was observed close to BH5. Access to these boreholes is restricted |

## AFRICAN OFFICES

### South Africa

**CAPE TOWN**

**T: +27 21 461 1118**

**FOURWAYS**

**T: +27 11 467 0945**

**SOMERSET WEST**

**T: +27 21 851 3348**

### Namibia

**WINDHOEK**

**T: + 264 61 231 287**

**SWAKOPMUND**

**T: + 264 64 402 317**