DHS GROUNDWATER
CONSULTING SERVICES

WATER USE LICENCE APPLICATION
Geohydrological Assessment

12 October 2021

Prepared for:

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DHS GROUNDWATER CONSULTING SERVICES

PROJECT TEAM

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Report: DHS-21-119

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Executive Summary

Balderja (Pty) Ltd is in the process of developing nut orchards and various crops on Portions 12, 15 and 17 of the Farm Redford 232, hereafter also referred to as the site. Water for the project will be sourced from groundwater through abstraction from boreholes and as part of the environmental authorisations, the water use needs to be licensed. Balderja (Pty) Ltd therefore appointed DHS Groundwater to conduct a geohydrological assessment as part of the Water Use License Application (WULA).

The most important findings of the assessment are summarised in the following table:

Geohydrological Characteristics	Balderja
Geology:	Goudini Formation (sandstone & quartzitic sandstone) of the Table Mountain Group (TMG) which forms part of the Cape Supergroup. No major fault lines or lineaments is shown on a local scale.
Aquifer Types:	Hard rock/Secondary fractured aquifers.
Aquifer Classification:	Minor Aquifer System
Borehole Yields:	2 L/s
Depth to Water Table:	~88 meters below ground level
Groundwater Quality:	Except for slightly elevated Iron concentrations, all analysed parameters comply with SANS241 drinking water limits. TDS of 172 mg/l.
Regional Groundwater Use:	Domestic & Agriculture (Irrigation)
Mean Annual Rainfall:	778 mm/a
Recharge:	37 - 50 mm/a (4.8% - 6.4% of MAP)
Groundwater available for abstraction from GRU:	0.080 Mm^3/a
Water Demand:	0.069 Mm^3/a
Cumulative Sustainable Yield from tested borehole(s):	0.069 Mm^3/a

Geohydrological Characteristics	Balderja
Volume to be applied for:	0.069 Mm^3/a

Based on the field work, interpretation of available and newly acquired data, the abstraction of groundwater from the site will have an overall "negligible – negative" impact on the investigated geohydrological environment after implementation of appropriate mitigation measures. During the rating and ranking procedure of impacts, all identified impacts could be countered by appropriate mitigation.

Based on the water balance results, it is recommended to apply for an allocation of 0.069 Mm^3/annum which places the application in Category B (medium scale abstractions: 60% -100% recharge to the GRU). The tested boreholes will be able to supply in 100% of the demand, as well as the applied volume.

From a water quality point of view, all of the parameters analysed for in the on site production borehole (DBH1) (except for slightly elevated Iron concentrations) comply with the SANS241 drinking water limits.

EC, TDS, Chloride, Sodium, Manganese and Iron in neighboring borehole DHC1 exceeds the SANS241 drinking water limits making the water unfit for human consumption without prior treatment.

It is proposed that the applicant consult an applicable agricultural specialist to assess water quality criteria to make judgements on the fitness of water to be used for irrigation of the intended crop(s), its effects on soil properties, soil salinity tolerance of the intended crops and how these effects may be mitigated and possible treatment options, if necessary.

It is the assessor's professional opinion that adequate information was available to appropriately assess the impact of groundwater abstraction from the production boreholes on the geohydrological environment. Based on the results, it is recommended that the application be approved. It is however imperative that the applicant implements the proposed "Environmental Management & Groundwater Monitoring Program". Production boreholes should be equipped as follow:

- Installation of a 32 mm LDPE observation pipe from the pump depth to the surface, open at the bottom. This allows for a 'window' of access down the borehole which enables manual water level monitoring and can house an electronic water level logger if required.
- Installation of a sampling tap (to monitor water quality).
- Installation of a flow volume meter (to monitor abstraction rates and volumes).
- The appropriate borehole pump must be installed, i.e. not an over-sized pump that is choked with a gate valve. If the monitoring shows that more water can be abstracted, then duty cycles (i.e. the duration of pumping time) may be increased, and not the flow rate.

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List of Abbreviations

Term	Definition
%	Percentage
CDT	Constant Discharge Test
CFB	Cape Fold Belt
CFU	Colony Forming Unit
DEA	Department of Environmental Affairs
DRO	Diesel Range Organics
DWAF	Department of Water Affairs & Forestry
DWS	Department of Water & Sanitation
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Program
EWR	Ecological Water Requirement
GA	General Authorisation
GMA	Groundwater Management Area
GMU	Groundwater Management Unit
GQM	Groundwater Quality Management
GRDM	Groundwater Resource Directed Measures
GRO	Gasoline Range Organics
GRU	Groundwater Resource Unit
Ha	Hectare
K	Hydraulic Conductivity
km	Kilometre
km^2	Square Kilometre
l/h	litres/hour
l/s	litres/second
LDPE	Low density polyethylene
M	meter
m/d	Meters per day

Term	**Definition**
m^3	Cubic Meters
m^3/a	Cubic Meters/annum
$m^3/ha/a$	Cubic Meters/hectare/annum
mamsl	meters above mean sea level
mbcl	meters below casing level
mbgl	meters below ground level
ML/d	Mega Liter/day
mm/a	Millimetres/annum
Mm^3/a	Million Cubic Meters/annum
mS/m	Millisiemens per meter
NEMA	National Environmental Management Act
NGA	National Groundwater Archive
nm	not measured
NTU	Nephelometric Turbidity Units
NWA	National Water Act
^oC	Degrees Centigrade
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
SANS	South African National Standards
SWL	Static water level
T	Transmissivity
TMG	Table Mountain Group
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
WARMS	Water Use Authorization & Registration Management System
WRC	Water Research Commission
WULA	Water Use Licence Application

1 Introduction

Balderja (Pty) Ltd is in the process of developing nut orchards and various crops on Portions 12, 15 and 17 of the Farm Redford 232, hereafter also referred to as the site. Water for the project will be sourced from groundwater through abstraction from boreholes and as part of the environmental authorisations, the water use needs to be licensed. Balderja (Pty) Ltd therefore appointed DHS Groundwater to conduct a geohydrological assessment as part of the Water Use License Application (WULA).

2 Geographical Setting

2.1 Site Location

The site is located approximately 13km north-east of the town of Plettenberg Bay, within the Western Cape Province. It covers an area of approximately 42 ha (Map 1, Appendix A).

2.2 Topography and Drainage

The site is located in quaternary catchment K60E within the Gouritz Water Management Area (WMA) at an elevation of ~230 mamsl (with a variation of less than 10% across the site).

The site is characterized by gently sloping topography and the majority of local drainage from the site is generally in a southerly direction towards two south flowing tributaries of the Whiskey Creek flowing in a westerly direction towards the Keurboomsriver.

2.3 Climate

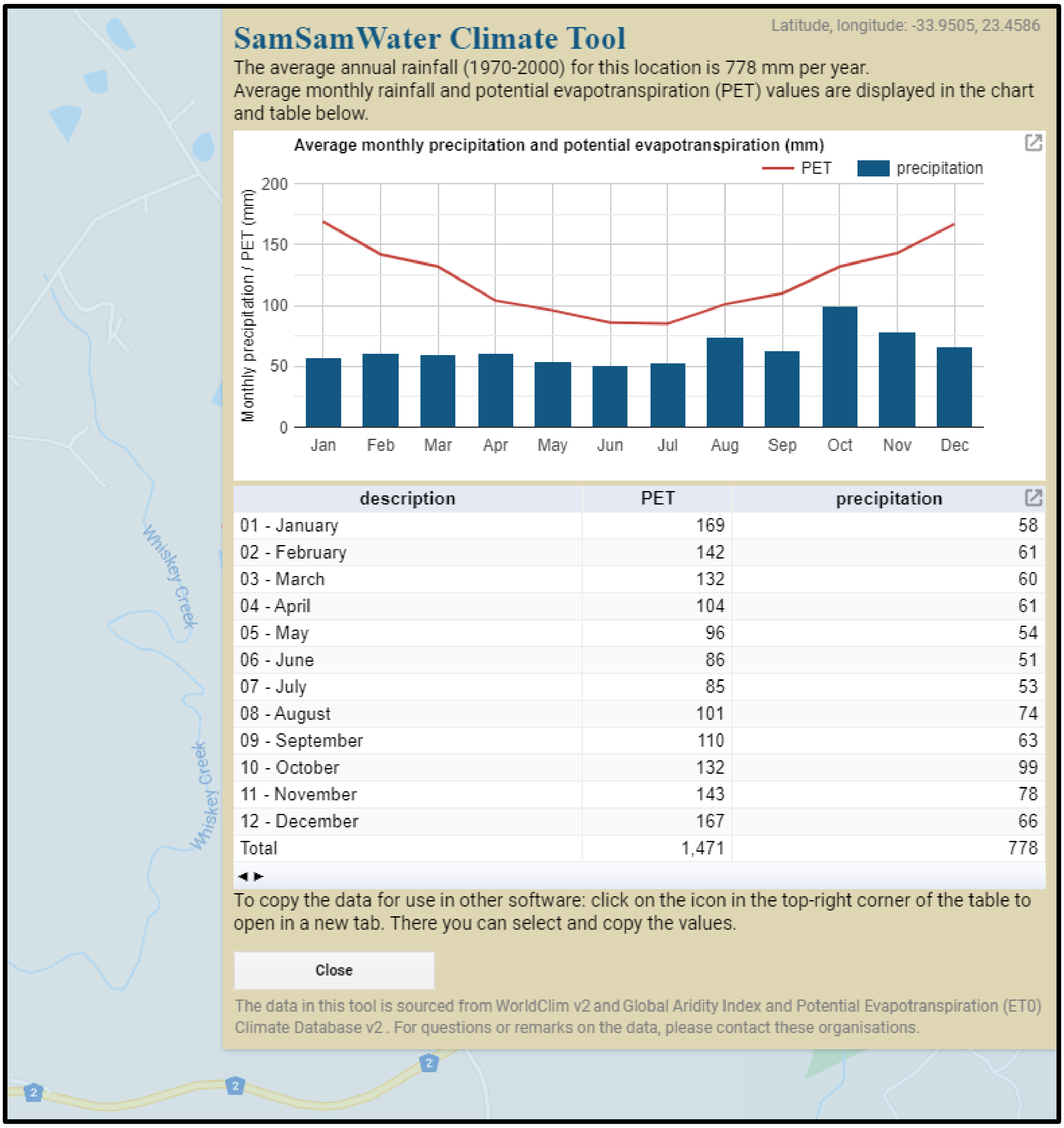
The area experiences a warm temperate climate, with year-round rainfall. The average daily minimums are 18°C for February and 10°C for July, whilst the average daily maximums are 24°C for February and 19°C for August. The highest temperatures reach above 30°C, generally associated with northerly Berg Winds typically occurring in autumn, whilst temperatures can get close to 0°C on still, clear nights in winter, typically after the passage of a cold front. However, on average, temperatures are mild due to the proximity of the Indian Ocean and moderately humid conditions.

Winds are generally light to moderate, with the most common direction being from the west.

Winter rain can come from large cold front systems that sweep across the Cape, particularly in late winter/spring, whilst summer rain comes largely from moisture advected off the Indian Ocean, associated with the South Indian Ocean High Pressure cell, feeding moist air inland to power the low pressure thunderstorm systems over the interior of the country.

Meteriological data obtained from SamSam Water Climate Tool[1] is presented in Figure 1. Figures of 778 mm for the mean annual precipitation (MAP) and 1471 mm for the mean annual evaporation (MAE) is reported. The MAE exceeds the MAP by an order of magnitude, resulting in a negative moisture index. Rainfall within the study area is bimodal where both summer and winter rainfall occurs, a feature typical of the south-east coastal region of the country.

[1] https://www.worldclim.org/ & Global Aridity Index and Potential Evapotranspiration Climate Database v2



description	PET	precipitation
01 - January	169	58
02 - February	142	61
03 - March	132	60
04 - April	104	61
05 - May	96	54
06 - June	86	51
07 - July	85	53
08 - August	101	74
09 - September	110	63
10 - October	132	99
11 - November	143	78
12 - December	167	66
Total	1,471	778

Figure 1. Precipitation and Evapotranspiration within the project area

3 Scope of Work

The objective of this assessment is to:

- Complete a geohydrological characterization of the groundwater in the vicinity of the site;
- Evaluate the proposed production boreholes in terms of yield and quality;
- Complete an assessment of the groundwater use in the area by means of a hydrocensus up to a maximum distance of a 1km radius;
- Perform a Rapid Reserve Determination in support of a Water Use License Application (WULA) in terms of Section 21 of the National Water Act (NWA), 1998 (Act 36 of 1998)[2].
- Evaluate predicted impacts of groundwater abstraction on the receiving geohydrological environment;
- Propose measures to mitigate identified negative impacts;
- Develop a monitoring program as part of an environmental management plan;
- Document the above findings in a format fully compatible with the requirements for a WULA (Appendix 2) which is to be submitted to the Department of Water and Sanitation (DWS).

This report is not intended to be an exhaustive description of the assessment, but rather serves as a specialist geohydrological assessment to evaluate the overall geohydrological character of the site, to inform the impact assessment, and propose mitigation measures where applicable.

4 Methodology

Reporting is based on and limited to results and observations made during geophysical surveys, drilling, test pumping, hydrocensus and the collation of available information. The work completed for the purposes of compiling a geohydrological report comprised the following:

4.1 Desk Study

Undertake a desk study of existing information available from relevant literature, the National Groundwater Archive (NGA)[3], the Water Use Authorization & Registration Management System (WARMS) and published geological and geohydrological maps and reports.

4.2 Site Visit & Hydrocensus

A site visit was conducted to evaluate the geology, geohydrology and potential receptors of possible groundwater impacts (quality and quantity) emanating from groundwater abstraction. A hydrocensus was carried out within the Groundwater Resource Unit, up to a maximum distance of a 1km radius from the site to identify legitimate groundwater users, the groundwater potential and quality. Where possible, groundwater levels were also measured to assist in the understanding of groundwater flow within the project area. Water samples were collected from selected boreholes and submitted for analysis of the major ions and trace elements.

[2] South African National Water Act (Act 36 of 1998)

[3] http://www3.dwa.gov.za/NGANet/Security/WebLoginForm.aspx

4.3 Test Pumping

A seventy-two-hour constant discharge test followed by recovery monitoring was conducted on the newly drilled production borehole. Test pumping was conducted as per SANS 10299-4:2003 standards[4]. The data was scientifically analysed to calculate the sustainable yield of the tested borehole. A water sample was collected and submitted to an SANAS accredited laboratory for the analysis of the major ions and trace elements.

4.4 Aquifer Vulnerability Assessment

The national scale groundwater vulnerability map, which was developed according to the DRASTIC methodology (DWAF, 2005)[5] and recompiled in 2013 was used to assess the project area in terms of "Aquifer Vulnerability". Aquifer Vulnerability can be defined as *"the likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer".*

4.5 Water Balance & Reserve Determination

The "Reserve" and groundwater available for abstraction was calculated through a "Rapid Reserve Determination" using the "Groundwater Resources Directed Measures" software[6] developed by the former Department of Water Affairs and Forestry (DWAF) as basis.

4.6 Aquifer Characterisation

The aquifer(s) underlying the project area was classified in accordance with "A South African Aquifer System Management Classification"[7] developed by the Water Research Commission and DWAF.

4.7 Impact Assessment

The methodology to determine the significance of the potential impacts of groundwater abstraction was developed in 1995 and has been continually refined to date through the application of it to over 400 Environmental Impact Assessment (EIA) processes. The methodology is broadly consistent to that described in the Environmental Impact Assessment Regulations[8] in terms of the NEMA[9].

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[4] South African National Standard. Development, maintenance and management of groundwater resources. Part 4: Test-pumping of water boreholes (SANS 10299-4:2003, edition 1.1). ISBN 978-0-626-32920-4

[5] DWAF, 2005. Groundwater Resources Assessment Project, Phase II (GRAII). Department of Water Affairs and Forestry, Pretoria.

[6] "Groundwater Resources Directed Measures" Software (Version 4.0.0.0). Department of Water Affairs & Water Research Commission.

[7] Department of Water Affairs and Forestry & Water Research Commission (1995). A South African Aquifer System Management Classification. WRC Report No. KV77/95.

[8] Environmental Impact Assessment Regulations, 2014 published under Government Notice No. 982 in Government Gazette No. 38282 of 4 December 2014

[9] National Environmental Management Act, 1998 (Act No. 107 of 1998) ("NEMA")

The risk associated with the groundwater abstraction for the property pertains to the operational phase only. Each impact was assessed individually and graded using a numerical system on the following factors:

- Duration
- Extent
- Intensity
- Probability.

The values assigned to each factor were used to calculate the significance of each impact. Each individual impact was assessed and re-assessed after the appropriate mitigation was applied.

The "Impact Assessment Methodology" is presented in Appendix C.

4.8 Reporting

A technical report was compiled broadly consistent with applicable sections of the proposed geohydrology template presented in the *"Regulations regarding the Procedural Requirements for Water Use Licence Applications and Appeals.[10]"*.

5 Regional and Local Geology

The project area is located within the Cape Fold Belt (CFB). The CFB, is a 1300 km mountainous fold-thrust belt along the southern and western margins of South Africa. These folds and thrusts of sedimentary sequences, regarding the genesis of the CFB, was caused by 4 major phases of deformation. These folds predominantly verge to the north due to pressure from the south during continental collision and break-up of Gondwana. Moreover, the Cape Fold Belt consists largely of Paleozoic aged sedimentary and meta-sedimentary rocks of the Cape Supergroup. In turn, the Cape Supergroup is subdivided into 3 major Groups: Table Mountain, Bokkeveld and Witteberg.

Based on the 1:250 000 Geological Series (3322 Oudshoorn[11]) the site is underlain by the Goudini Formation of the Table Mountain Group (TMG) which forms part of the Cape Supergroup (Map 2, Appendix A). In addition, the Goudini Formation is underlain by the Cederberg (black shale), Peninsula (cross-bedded quartzites, subordinate shale) and Sardinia Bay (cross-bedded quartzites, grey to black pelites, laminated grey-brown psammites, subordinate conglomerate) Formations.

No major fault lines or lineaments is shown on a local scale. The lithostratigraphy of the regional geology is shown in Table 1.

Table 1. Lithostratigraphy of regional geology

Supergroup	Group	Formation	Lithology
Cape Supergroup	Table Mountain	Skurweberg (Sk)	Medium to Coarse Grained Quartzitic Sandstone, Subordinate Shale.
		Goudini (St)	Sandstones and Quartzitic Sandstones with subordinate Siltstone and Shale.
		Peninsula (Op)	Medium to Coarse Grained Quartzitic Sandstone.

10 Regulations regarding the Procedural Requirements for Water Use Licence Applications and Appeals. (Gazette No. 40713, GoR. 267, 24 March 2017)

11 1:250 000 Geological Map (3322 Oudshoorn). Geological Survey, 1979.

6 Regional Geohydrology

Both the lithology and structural geology have a major bearing on the groundwater potential of the area. In their pristine state, the consolidated geological units have negligible groundwater potential. It is the secondary structural features that give the units groundwater potential. These secondary structures are usually associated with faults, fractures and weathering which gives rise to discrete zones of secondary permeability.

Unless otherwise stated, the published 1:500 000 General Hydrogeological Map[12] and associated explanatory booklet[13] was used as basis to describe the regional geohydrological conditions.

6.1 Aquifer Types and Borehole Yields

Groundwater within the project area occur predominantly within fractured rock aquifers with reported yields of 0.5 - 2 L/s.

6.2 Depth to Groundwater

The modelled 1km x 1km "Raster Waterlevel Grid" reports a static water level of 49.24 mbgl[14] for the area. It must be stated that large scale raster water level grids are not intended to define water level depths on small scale and therefore a hydrocensus was conducted to get an better understanding of the regional static groundwater levels.

6.3 Groundwater Recharge and Baseflow

The study area falls within quaternary catchment K60E. The mean annual precipitation and annual recharge figures for the study area is presented in Table 2. Vegter's (1995)[15] recharge and baseflow maps were used to obtain a first estimate of regional recharge and groundwater contribution to rivers and streams (baseflow).

Table 2. Regional Rainfall, Recharge and Baseflow

Mean Annual Precipitation (mm):	778
Annual Recharge (mm):	37 – 50
Percentage Recharge of MAP:	4.8% - 6.4%
Annual Baseflow (mm):	10 – 25
Percentage Baseflow of MAP:	1.2% - 3.2%

[12] 1:500 000 General Hydrogeological Map, Oudshoorn 3321 (1999)

[13] Meyer, P.S. (1999). An explanation of the 1:500 000 General Hydrogeological Map, Oudshoorn 3320. Department of Water Affairs and Forestry, Pretoria.

[14] DWA (Department of Water Affairs). (2005.). Groundwater Resource Assessment II

[15] Vegter, J.R. (1995). An explanation of a set of national groundwater maps; WRC Report No. TT 74/95. Water Research Commission, Pretoria.

Due to the fractured nature of the sandstones in generally high rainfall regions, recharge is favorable, and infiltration rates of up to 15% of the mean annual precipitation in certain areas are not unrealistic (Meyer, 1999).

6.4 Groundwater Quality

Electrical Conductivity (EC) of groundwater in the TMG is generally between 10 and 100 mS/m and displays a sodium-chloride-magnesium nature. Less potable groundwater is however occasionally drawn from boreholes drilled into interbedded shaly layers.

6.5 Aquifer Vulnerability

The national scale Groundwater Vulnerability Map, which was developed according to the DRASTIC methodology (DWAF, 2005) and recompiled in 2013 was used to assess the aquifers underlying the site in terms of "Aquifer Vulnerability". Aquifer Vulnerability can be defined as *"the likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer"*.

The DRASTIC method takes into account the following factors:

- D = depth to groundwater (5)
- R = recharge (4)
- A = aquifer media (3)
- S = soil type (2)
- T = topography (1)
- I = impact of the vadose zone (5)
- C = conductivity (hydraulic) (3)

The number indicated in parenthesis at the end of each factor description is the weighting or relative importance of that factor.

Aquifer Vulnerability is rated as follows:

Green represents the least vulnerable region that is only vulnerable to conservative pollutants in the long term when continuously discharged or leached
Yellow represents the moderately vulnerable region, which is vulnerable to some pollutants, but only when continuously discharged or leached.
Red represents the most vulnerable aquifer region, which is vulnerable to many pollutants except those strongly absorbed or readily transformed in many pollution scenarios.

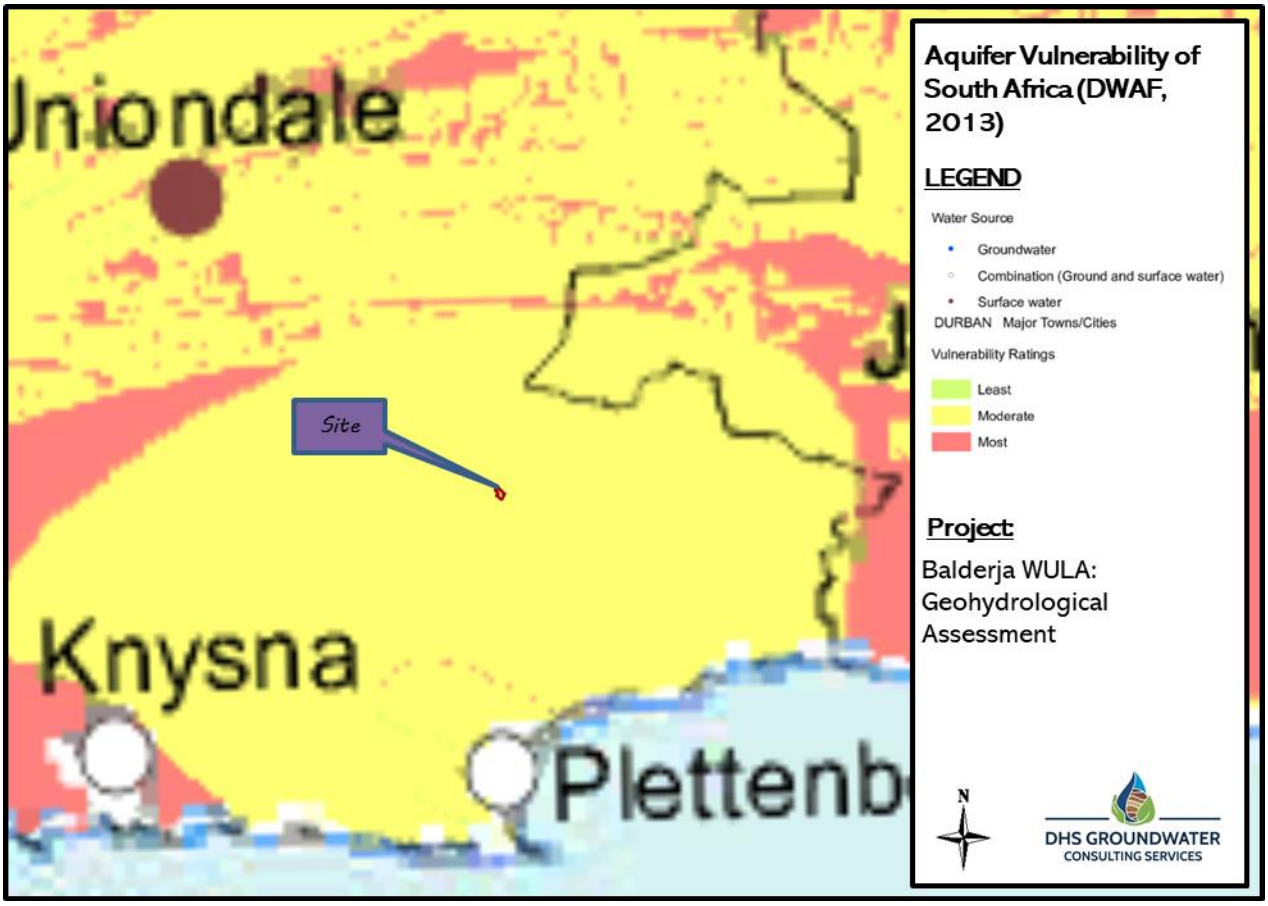

Figure 2. Regional groundwater vulnerability for the study area (DWAF, 2013).

The vulnerability of the aquifers within the project area is rated as "moderately vulnerable to pollutants".

7 Delineation of the Groundwater Resource Unit

A "Geohydrological Response Unit" (GRU), also referred to as a "Groundwater Resource Unit", is defined as a groundwater system that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit. Criteria to map a GRU would include:

1. Areas of similar geology;
2. Groundwater elevations generally mimic surface topography, and groundwater flows from higher lying ground towards lower lying springs or valleys (drainage lines), therefore surface water catchment boundaries may be used as surrogate for groundwater divides;
3. Rivers/Streams acting as a constant head boundary;
4. Impermeable dykes/lineaments acting as no-flow boundaries; and lastly
5. Expert judgement and interpretation.

For this study area there are clear drainage features that enable the definition of a more localised aquifer (i.e. a GRU). The GRU for the underlying fractured aquifer has been defined using topographical highs to the north and west, while the Whiskey Creek forms the majority of the eastern boundary. Although the GRU stretches over two geological formations, they all form part of the same group (Table Mountain), have similar lithology and can thus be regarded as one aquifer or resource unit (Map 2 & 3 in Appendix A).

The mapped GRU covers a total area of 251 ha.

8 Site Specific Assessment

8.1 Existing Groundwater Information

8.1.1 National Groundwater Archive

A desktop hydrocensus was carried out within the GMU as a minimum, but it extended to at least a one-kilometre search radius around the site boundaries. This was done to determine groundwater use in the area. A search of the National Groundwater Archive (NGA), which provides data on borehole positions, groundwater chemistry and yield, when available, was carried out to identify proximal boreholes. These sites are then typically verified in the field and provide background information on the area, should they exist.

Under circumstances where the coordinate accuracy of most of the boreholes enumerated in the NGA is not better than 10 000 m, their positions are at least constrained to the boundaries of the topocadastral farms on which they are located. The associated geohydrological data and information therefore provides only a broad overview of groundwater conditions rather than site-specific information.

Limited borehole data is available for the area and a search to the NGA produced no boreholes listed within a 5km radius from the site.

8.1.2 Water Use Authorization & Registration Management System (WARMS)

WARMS data (updated 15 June 2021) was acquired for the study area to establish the volume of lawful groundwater use within the GRU. No registered groundwater users were listed within the delineated GRU. The closest registered groundwater users are located at a distance of more than 4km from the site.

8.2 Hydrocensus

A hydrocensus was conducted on 21 September 2021 to establish groundwater use within the larger project area. The hydrocensus extended to a maximum distance of ~1km from the site boundaries, except where a river or a surface water body exist. The hydrocensus did not extend past such a feature as surface water bodies are usually hydraulically connected to an aquifer, act as a constant-head boundary and a groundwater pollution plume or cone of depression would theoretically not extend past a constant head boundary. Any information pertaining to the abstraction, yield and quality of groundwater was sought.

Apart from the one existing borehole located within the site boundaries, an additional three boreholes were identified on neighbouring properties. These boreholes are however not located within the delineated GRU. No boreholes could be found on neighbouring properties located within the GRU.

A summary of the most important data pertaining to the boreholes are summarised in Table 3. The borehole locations are presented in Map 4 in Appendix 1.

From the hydrocensus data it can be concluded that there is limited groundwater use within the GRU and where groundwater is abstracted, it is mainly used for domestic and agricultural purposes (irrigation). High EC values often exceeding the SANS drinking water standards limits the water use for domestic purposes without prior treatment.

Reported yields are generally in accordance with published data.

Apart from limited seasonal fluctuations in groundwater levels (<10%, based on previous experience in similar geology and rainfall), groundwater yields will remain consistent, irrespective of the season. The groundwater information can therefore be gathered indeterminate of the season.

Table 3. Details of boreholes identified during hydrocensus

BH nr	Coordinates Decimal Degrees (WGS84)	Depth (m)	Yield (l/s)	EC (mS/m)	Static water level (mbc)	Equipment	Water Use	Property Owner (Cell nr)
DBH1	S 33.95100 E 23.44480	252	2.2	22	87.96	None	Irrigation	Denina Bernard (082 781 3155)
DHC1	S 33.94355 E 23.45718	163	4.2	211	2.93	Subm. Pump	Irrigation	Johan & Brenda Niehaus (082 880 7235)
DHC2	S 33.947195 E 23.460486	167	0.5	36	nm	Subm. Pump	Domestic	Johan & Brenda Niehaus (082 880 7235)
DHC3	S 33.94677 E 23.46241	228	1.5	160	36	None	Domestic	Trevor Daws (082 852 8192)

DBH1

DHC1

DHC2

DHC3

Figure 3. Borehole Photos

8.3 Groundwater Flow Direction

Generally, groundwater elevations mimic surface topography, and groundwater flows from higher lying ground towards lower lying springs or valleys (drainage lines). The general groundwater flow direction will thus be in a southern direction.

8.4 Pumptesting

The newly drilled borehole was pumptested from 27 August 2021 to 4 September 2021. The pump test was conducted by Welltek Services and the pumptesting data is attached in Appendix 4.

8.4.1 Description of a Pumptest

The efficient operation and utilization of a borehole require insight into and an awareness of its productivity and that of the groundwater resource from which it draws water. This activity, which is also known as pumptesting, provides a means of identifying potential constraints on the performance of a borehole and on the exploitation of the groundwater resource.

The following tests were performed on the boreholes: (1) Step-Drawdown Test and (2) Constant Discharge Test.

8.4.1.1 Stepped Discharge Test

The purpose of the step drawdown test is to establish the efficiency of a single borehole and to provide preliminary information on the yield of the borehole (both from a quantitative and qualitative perspective). Often the insights gained from the step-test are used in the design and pumping rate of the constant discharge test.

8.4.1.2 Constant Discharge Test

A constant discharge test is performed to assess the productivity of the aquifer according to its response to the abstraction of water. This test entails pumping the borehole at a single pumping rate which is kept constant for an extended period. The test duration in this instance was 72 hours.

8.4.1.3 Recovery Monitoring

This test provides an indication of the ability of a borehole and groundwater system to recover from the stress of abstraction. This ability can again be analysed to provide information about the hydraulic properties of the groundwater system and arrive at an optimum yield for the medium to long term utilizations of the borehole.

8.4.2 Results & Data Interpretation

To estimate optimum pumping rates, pumping schedules and aquifer parameters, the pumptesting data were analysed by means of an Excel based software package developed by Van Tonder et al., (2002)[16]. In the software package, the Flow Characteristic method (FC-method), Cooper-Jacob-, FC Non-Linear- and Barker methods were used to estimate a risk-based sustainable yield for the borehole, as well as aquifer parameters such as transmissivity (T) and the storage coefficient (S).

[16] FC program for Aquifer Test Analysis (2013 version). Prof. Gerrit van Tonder, Fanie de Lange and Modreck Gomo. Institute for Groundwater Studies, University of the Free State.

Summary		Denina Bernard - Borehole DBH1						
Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)		Late T (m^2/d)	S	AD used
☑	Basic FC	2.05	1.04	5		4.2	2.20E-03	70.0
☐	Advanced FC							
☐	FC inflection point							
☑	Cooper-Jacob	2.20	1.42			7.8	8.57E-05	70.0
☐	FC Non-Linear							
☑	Barker	2.23	1.32	K_f =	3	S_s =	1.00E-07	70.0
	Average Q_sust (l/s)	2.16	0.09	b =	0.68	Fractal dimension n =	2.14	

Recommended abstraction rate (L/s)		2.16	7776	l/hr	For 24 hrs per day
Hours per day of pumping (L/s)	12	3.06	11016	l/hr	12 hrs per day
Hours per day of pumping (L/s)	10	3.35	12060	l/hr	10 hrs per day
Hours per day of pumping (L/s)	8	3.74	13464	l/hr	8 hrs per day

Amount of water allowed to be abstracted per month	5598.72	m^3
Borehole could satisfy the basic human need of	7465	persons
Is the water suitable for domestic use (Yes/No)	-	

Recommended pump depth below surface (m)	180		
Total Casing length	250		
Blow yield (l/s)	-		
Expected dynamic water level over 24hr pump	125	mbcl	metres below casing level
Critical depth that water level must not exceeded	160	mbcl	
Depth of BH	250	mbcl	
Static Water Level	87.03	mbcl	

Figure 4. Summary of sustainable yield calculations

The calculated sustainable yield for the boreholes together with the necessary information to equip the borehole is presented in Table 4.

Table 4. Management Recommendations for the tested boreholes

Borehole nr.	Coordinates (WGS84)		Depth (m)	Static Water Level (m)	#Dynamic WL (m)	Sustainable Yield (l/h) Pumping 24 hours/day	Proposed depth of pump installation (m)	Volume/day (m^3)
	S	E						
DBH1	33.95100	23.44480	250	87.03	125	7920	180	190.08
							Total Volume (m^3/day)	190.08
							Total Volume (Mm^3/annum)	0.069

 # Dynamic water level - Level at which the water level in the borehole stabilises after continuous pumping. To be used to calculate hydraulic heads when sizing submersible pumps.

The total volume of water abstracted from the tested borehole should never exceed the calculated water available for abstraction from the GRU. If the sustainable yield of the tested boreholes exceeds the water available for abstraction from the GRU, borehole yields or duty cycles need to be reduced.

In this instance, the water demand of 0.069 Mm^3/a is equal to the tested borehole's capacity, and within the volume of water available for abstraction within the GRU (section 9.4).

8.5 Groundwater Quality

A groundwater sample was collected for analysis of the major ions and trace elements during pumptesting of the production borehole (DBH1). A water sample was also collected from a borehole located on one of the neighboring properties (DHC1). The laboratory reports are presented in Appendix E.

Water quality results were compared with the SABS drinking water standards (SANS 241-1:2015, edition 2)[17] (Table 5). Water is classified unfit for human consumption if the Standard Limits are exceeded. It must be emphasized that although the water use will mainly be used for irrigation purposes, it was compared to drinking water standards which is more stringent than irrigation standards.

Table 5. Water quality results compared to SANS 241-1:2015 (edition 2) drinking water standards

Sample Nr.	DBH1	DHC1							Standard Limits
pH	6.00	5.90							5.0 - 9.7
EC	27	211							170
TDS	172	1350							1200
T-Alk	13	16							~
Cl	67.9	699.4							300
SO_4	6.0	26.5							250
NO_3-N	0.00	0.00							11
NH_4-N	0.00	0.00							1.5
Ca	3.55	34.96							~
Mg	2.85	47.30							~
Na	39.48	312.59							200
K	0.00	11.62							~
Fe	0.56	39.06							0.3
Mn	0.01	1.28							0.1
Cu	0.00	0.00							2
Zn	0.34	0.81							5

Notes
Yellow = Acceptable
Exceeds standard limits
Blank = Not Analysed
0 = below detection limit of analytical technique

EC measurements in mS/m, Turbidity in NTU, other parameters in mg/ℓ

Except for slightly elevated Iron concentrations, in all of the parameters analysed for in the on site production borehole (DBH1) comply with the SANS241 drinking water limits.

EC, TDS, Chloride, Sodium, Manganese and Iron in neighboring borehole DHC1 exceeds the SANS241 drinking water limits making the water unfit for human consumption without prior treatment.

It is proposed that the applicant consult an applicable agricultural specialist to assess water quality criteria to make judgements on the fitness of water to be used for irrigation of the intended crop(s), its effects on soil properties, soil salinity tolerance of the intended crops and how these effects may be mitigated and possible treatment options, if necessary.

[17] SABS drinking water standards (SANS 241-1:2015) Second Edition. SABS Standards Division, March 2015. ISBN 978-0-626-29841-8

9 Reserve Determination & Water Balance

The sustainable volume of groundwater that can be abstracted from the aquifer(s) underlying the site was determined using the GRDM software (version 4.0.0.0 (2010)) as basis. It takes the reserve into account when calculating the volume of water available for abstraction.

The assessment was done on a "rapid" level. The data used for the calculation was derived from the WRC90 dataset contained in the "GRDM" software driven by the Resource Directed Measures from the Department of Water and Sanitation. The site falls within quaternary catchment K60E and the default values, except where updated information was available, were used in the assessment in order to develop some guidance on the potential impact of the abstraction on the overall groundwater use in the catchment. It must be stated that the results achieved for the quaternary catchment is not necessarily applicable on the delineated Groundwater Resource Unit (GRU) due to compartmentalisation. Geological lineaments may act as no-flow boundaries while rivers/streams may act as constant head boundaries subdividing the quaternary catchments in smaller GRU's with different exploitation potentials. The results of the GRU should rather be considered when allocating a volume of groundwater for abstraction for this specific project.

9.1 Introduction

Definition of Reserve: *"The quantity and quality of water required to supply basic needs of people to be supplied with water from that resource and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources".*

To be able to quantify the groundwater component of the Reserve, the following relationship has to be solved:

$$\mathbf{GW_{allocate} = (Re + GW_{in} - GW_{out}) - BHN - GW_{Bf}}$$

where:	$GW_{allocate}$	=	groundwater allocation
	Re	=	recharge
	GW_{in}	=	groundwater inflow
	GW_{out}	=	groundwater outflow
	BHN	=	basic human needs
	GW_{Bf}	=	groundwater contribution to baseflow

Under the National Water Act (Act No. 36 of 1998) the water use must be authorised. The water will be abstracted from borehole(s), and used for commercial (agriculture/irrigation) purposes. Under these circumstances, the following (ground) water use is recognised as being relevant to the licence application:

- Section 21 (a) – taking water from a resource.

9.2 Water Demand and Abstraction Classification

The calculated water demand for the project is 0.069 Mm^3/annum. DWS categorises water use licence applications in three categories (presented in Appendix 2) based on the amount of recharge that is used by the applicant in relation to the specified property:

- Category A: Small scale abstractions (<60% recharge)
- Category B: Medium scale abstractions (60-100% recharge)
- Category C: Large scale abstractions (>100% recharge)

9.3 Assessment on Quaternary Level

The property falls within quaternary catchment K60E and the most salient parameters relevant to this catchment is presented in Table 6.

Table 6. Most salient parameters relevant to catchment K60E.

Area km²	Protected Area (km²)	GA (m³/ha/a)	Recharge (Mm³/a)	Population	Basic Human Need (Mm³/a)	EWR Baseflow (Mm³/a)	Reserve (Mm³/a)	Current use (Mm³/a)
110.2	49.7	400	5.33	14360	0.01	3.00	3.01	0.48

Keeping the water demand in mind, General Authorisation as a possible route can be excluded.

The values used in Table 6 originates from data contained in the GRDM software and the "current use" represents registered groundwater users as contained in the WARMS data base updated 15 June 2021.

9.3.1 Stress Classification

To provide a quantitative means of defining stress, a groundwater stress index was developed by dividing the volume of groundwater abstracted from a groundwater unit by the estimated recharge to that unit.

Stress Index = Abstraction/Recharge

= 0.48/5.33

= 0.09

The quaternary catchment is classified as Category B, which indicates "slight" levels of stress in terms of abstraction/recharge (Table 7).

Table 7. Guideline for determining the level of stress[18]

Present Status Category	Description	Stress Index (abstraction/recharge)
A	Unstressed or slightly stressed	<0.05
B		0.05 - 0.20
C	Moderately Stressed	0.20 – 0.40
D		0.40 – 0.65
E	Highly Stressed	0.65 – 0.95
F	Critically Stressed	>0.95

[18] Groundwater Resources Directed Measures Manual (WRC Report No TT299/07, April 2007)

9.3.2 Reserve & Water available for allocation

The following table summarizes the reserve and water available for abstraction from the quaternary catchment.

Table 8. A summary of the Reserve for quaternary the catchment K60E.

Quantification of Reserve: K60E	
Human Need:	
Population	1000
Basic human need [l/d/p]	25
Basic human need total [Mm³/a]	0.01
Recharge:	
Recharge [Mm³/a]	5.33
Baseflow:	
Baseflow [Mm³/a]	3.00
☑ Maint. low flow [Mm³/a]	3.00
☐ EWR [Mm³/a]	0.00
Flow:	
Net Flow [Mm³/a]	0.00
Reserve:	
Reserve as % recharge	56.5
Groundwater allocation [Mm³/a]	2.32
Current abstraction [Mm³/a]	0.48

From Table 8 it becomes evident that 56.5% of the recharge, with the greatest contribution coming from baseflow, is allocated to the Reserve and that 2.32 Mm^3/a is available for allocation. The current authorised abstraction from the catchment is 0.48 Mm^3/a which leaves a volume of 2.32 Mm^3/a available for allocation. This "current abstraction" represents registered groundwater users as contained in the WARMS data base up to 15 June 2021.

9.4 Assessment on Groundwater Resource Unit level

If the calculation is based on the GRU delineated for the project using Vegter's (1995) range of recharge and baseflow figures, the following emerges:

Table 9. Water Balance within the Groundwater Resource Unit

Area	Surface Area (ha)	Groundwater Recharge to GRU using recharge figure of 46 mm/a
GRU	251	115460 m^3/a
Recharge to GRU		0.115 Mm^3/a 316 m^3/day 3.7 l/second
Registered Use (WARMS)		0.0 m^3/a
RESERVE	Basic Human Need	365.0 m^3/a
	Base Flow (EWR)	14.0 mm/a 35140 m^3/a
Groundwater available for abstraction		79955 m^3/a 0.080 Mm^3/a 219055 l/day 2.5 l/second
Application (WULA)		0.069 Mm^3/a
WULA as % of Groundwater available in GRU		86.30 %

Based on the water balance results, it is recommended to apply for an allocation of 0.069 Mm^3/annum which places the application in Category B (medium scale abstractions: 60% -100% recharge to the GRU) see section 9.2. The tested boreholes will be able to supply in 100% of the demand, as well as the applied volume.

10 Aquifer Classification

The aquifer(s) underlying the project area were classified in accordance with “A South African Aquifer System Management Classification, December 1995” by Parsons. Classification has been done in accordance with the following definitions for Aquifer System Management Classes:

- Sole Aquifer System: An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.
- Major Aquifer System: Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (Electrical Conductivity of less than 150 mS/m).
- Minor Aquifer System: These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.
- Non-Aquifer System: These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Based on the available information it can be concluded that aquifer system in the study area can be classified as a “Minor Aquifer System”. The aquifer extent is limited, water quality inferior, but are still important for local supplies and in supplying base flow for rivers.

In order to achieve the Groundwater Quality Management Index a point scoring system, as presented in Table 10and Table 11 below, was used.

Table 10. Ratings for the Aquifer System Management and Second Variable Classifications:

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

Table 11. Ratings for the Groundwater Quality Management (GQM) Classification System:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	
Major Aquifer System:	4	
Minor Aquifer System:	2	2
Non-Aquifer System:	0	
Special Aquifer System:	0 - 6	
Aquifer Vulnerability Classification		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

The vulnerability, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, in terms of the above, is classified as medium (section 6.5). The level of groundwater protection based on the Groundwater Quality Management Classification:

GQM Index = Aquifer System Management x Aquifer Vulnerability

= 2 X 2 = 4

Table 12. GQM index for the study area

GQM Index	Level of Protection	Study Area
<1	Limited	
1 - 3	Low Level	
3 - 6	Medium Level	4
6 - 10	High Level	
>10	Strictly Non-Degradation	

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 4 for the study area, indicating that a "Medium" level of groundwater protection is required.

The values in Table 10 are naturally subjective, but is based on the aquifer descriptions given previously. The importance of each aquifer should provide guidance on the protection to be assigned to each area.

In terms of DWS's overarching water quality management objectives which is (1) protection of human health and (2) the protection of the environment, the significance of this aquifer classification is that if any potential risk exists, measures must be triggered to limit the risk to the environment. In this instance it would be the (1) protection of the "Minor Aquifer", (2) the Schedule 1 groundwater users in the area, and (3) maintain baseflow to the streams which drains the subject area.

11 Impact Assessment

The risk associated with groundwater abstraction at the site pertains to the operational phase only. The most significant impacts considered as part of the impact assessment is listed below. Each impact was assessed individually and graded using a numerical system to calculate the significance of each impact. Each individual impact was assessed and re-assessed after the appropriate mitigation was applied. A compressive summary of the assessed impacts, mitigation and significance of each impact is listed in the tables below.

11.1.1 Depletion of the groundwater resource due to over-abstraction

Ref:	1			
Project phase	Operation			
Impact	Depletion of the groundwater resource due to over-abstraction			
Description of impact	Over-abstraction of groundwater from boreholes is likely to lead to depletion of the water levels in the area over time. This can cause damage to the aquifer and might impact on neighbouring and registered groundwater users that are reliant on the same source of water. Reduced baseflow to streams/rivers and groundwater dependent eco systems (wetlands).			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	(1) Yield testing of boreholes as per “SANS 10299-4:2003" standards. Do not exceed calculated sustainable yield of boreholes. (2) Groundwater level monitoring - reduce abstraction in the event of anomolous lowering of groundwater levels. (3) Take "Ecological Water Reserve" into account during waterbalance.			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Medium term	Impact will last between 5 and 10 years	Brief	Impact will not last longer than 1 year
Extent	Local	Extending across the site and to nearby settlements	Very limited	Limited to specific isolated parts of the site
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Probable	The impact has occurred here or elsewhere and could therefore occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	High	The affected environmental will be able to recover from the impact
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance	After the implementation of mitigation measures, the significance of the impact becomes neglegible.			
Cumulative impacts	Since the impact is negligible negative with mitigation, cumulative impacts to groundwater with other projects are not anticipated.			

11.1.2 Groundwater quality deterioration as a result of over-abstraction

Ref:	2			
Project phase	Operation			
Impact	Groundwater quality deterioration as a result of over-abstraction			
Description of impact	Over-abstraction of groundwater from a borehole can potentially draw poorer water quality from the adjacent geohydrological environment into the borehole. This is likely to affect the groundwater quality in the area in general and might affect the supply in other boreholes within the fractured aquifer. Based on data acquired during the desk study and field measured EC, the water quality in boreholes located within the same GRU are in the same order of magnitude.			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	Do not exceed calculated safe yield of boreholes. Groundwater level & quality monitoring - reduce abstraction in the event of anomolous lowering of groundwater levels and/or deteriorating water quality.			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	impact will last between 1 and 5 years	Brief	Impact will not last longer than 1 year
Extent	Limited	Limited to the site and its immediate surroundings	Limited	Limited to the site and its immediate surroundings
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Negligible	Natural and/ or social functions and/ or processes are negligibly altered
Probability	Probable	The impact has occurred here or elsewhere and could therefore occur	Unlikely	Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance	After the implementation of mitigation measures, the significance of the impact becomes neglegible.			
Cumulative impacts	Since the impact is negligible negative with mitigation, cumulative impacts to groundwater with other projects are not anticipated.			

12 Environmental Management & Groundwater Monitoring Program

The main objective of the proposed and discussed mitigation measures, pertaining to the identified impacts, is to maintain and monitor the regional groundwater table and quality to:

- Ensure that Schedule 1 water users within the catchment have adequate water supply to sustain the basic human need.
- Ensure that registered groundwater use within the catchment have adequate water supply.
- Ensure that adequate water is available to maintain groundwater dependent ecosystems (baseflow feeding the rivers/streams draining the subject area and wetlands).

A groundwater monitoring program was developed to reach the resource quality objectives. The on-site production borehole needs to be included in the network and are summarised in Table 13 below.

Table 13. Boreholes to be included in Monitoring Network

Borehole(s)	Objective
DBH1	Impact Monitoring

Table 14 below presents the parameters and frequency that should form part of the groundwater monitoring program. It is proposed that the data should be captured into an appropriate electronic database for easy retrieval and submission to the relevant authority as required and reviewed by a geohydrologist on an annual basis to ensure the source is utilised in a sustainable manner.

Table 14. Proposed Monitoring Requirements

Class	Parameter	Frequency	Motivation
Physical	Static groundwater levels	Monthly	Time dependant data is required to understand the regional groundwater flow dynamics. A lowering in the static water levels may indicate that the aquifer is utilised in an unsustainable way and abstraction rates need to be decreased. Conditions of the Water Use Licence.
	Groundwater abstraction volumes	Monthly	Calculate monthly & annual abstraction volumes. Conditions of the Water Use Licence.
Chemical	Major ions and trace elements.	Bi-annually	Changes in chemical composition may indicate areas of groundwater contamination and be used as an early warning system to implement management/remedial actions. To determine whether the water is fit for the intended use. Conditions of the Water Use Licence.

13 Conclusion & recommendations

Based on the field work, interpretation of available and newly acquired data, the abstraction of groundwater from the site will have an overall "negligible – negative" impact on the investigated geohydrological environment after implementation of appropriate mitigation measures. During the rating and ranking procedure of impacts, all identified impacts could be countered by appropriate mitigation.

Based on the water balance results, it is recommended to apply for an allocation of 0.069 Mm^3/annum which places the application in Category B (medium scale abstractions: 60% -100% recharge to the GRU). The tested boreholes will be able to supply in 100% of the demand, as well as the applied volume.

From a water quality point of view, all of the parameters analysed for in the on site production borehole (DBH1) (except for slightly elevated Iron concentrations) comply with the SANS241 drinking water limits.

EC, TDS, Chloride, Sodium, Manganese and Iron in neighbouring borehole DHC1 exceeds the SANS241 drinking water limits making the water unfit for human consumption without prior treatment.

It is proposed that the applicant consult an applicable agricultural specialist to assess water quality criteria to make judgements on the fitness of water to be used for irrigation of the intended crop(s), its effects on soil properties, soil salinity tolerance of the intended crops and how these effects may be mitigated and possible treatment options, if necessary.

It is the assessor's professional opinion that adequate information was available to appropriately assess the impact of groundwater abstraction from the production boreholes on the geohydrological environment. Based on the results, it is recommended that the application be approved. It is however imperative that the applicant implements the proposed "Environmental Management & Groundwater Monitoring Program". Production boreholes should be equipped as follow:

- Installation of a 32 mm LDPE observation pipe from the pump depth to the surface, open at the bottom. This allows for a 'window' of access down the borehole which enables manual water level monitoring and can house an electronic water level logger if required.
- Installation of a sampling tap (to monitor water quality).
- Installation of a flow volume meter (to monitor abstraction rates and volumes).
- The appropriate borehole pump must be installed, i.e. not an over-sized pump that is choked with a gate valve. If the monitoring shows that more water can be abstracted, then duty cycles (i.e. the duration of pumping time) may be increased, and not the flow rate.

Disclaimer: *The calculated sustainable yield of the borehole(s) is based on data acquired during a short-term constant discharge test. The sustainable yield of a borehole may change for various reasons (lower than average rainfall, increased abstraction within the groundwater resource, mine dewatering, unknown geological boundary conditions, etc.). Continuous groundwater monitoring is critical to provide essential data needed to evaluate changes in the resource over time; as well as the long-term sustainability and status of an aquifer. In the event of anomalous groundwater level behaviour, abstraction rates and pumping cycles should be adapted until pre-operational groundwater levels have been reached.*

14 References

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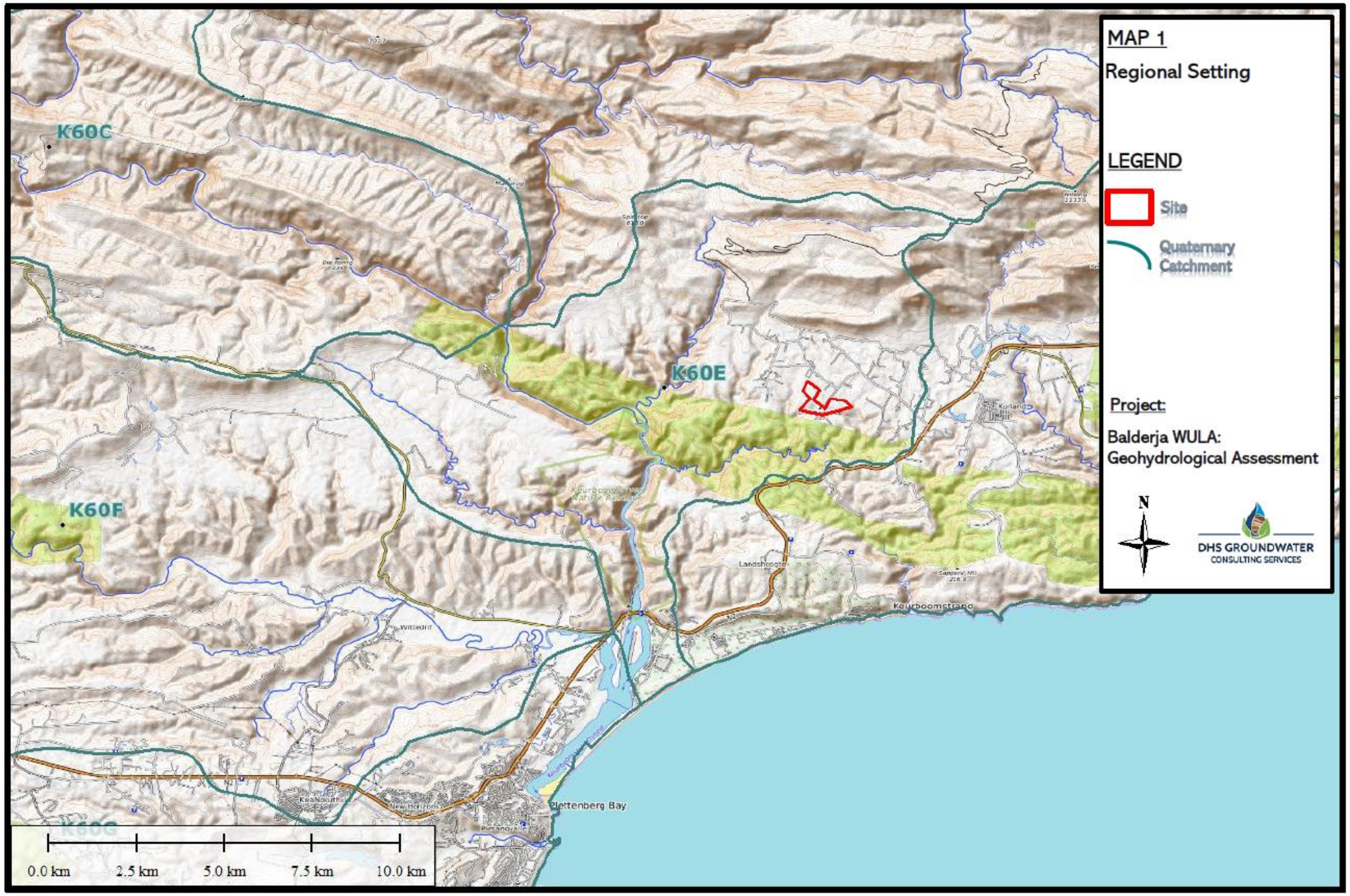
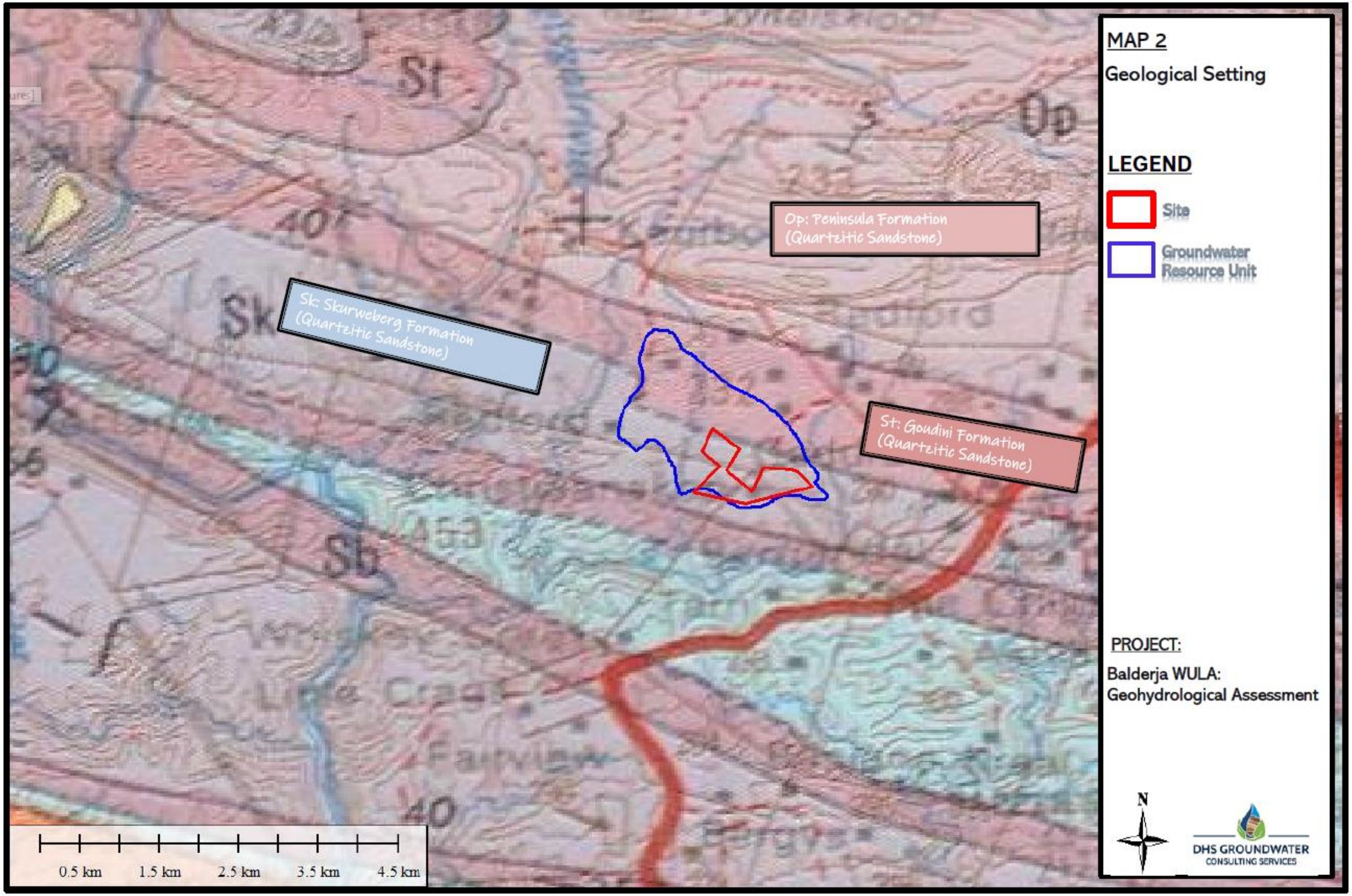
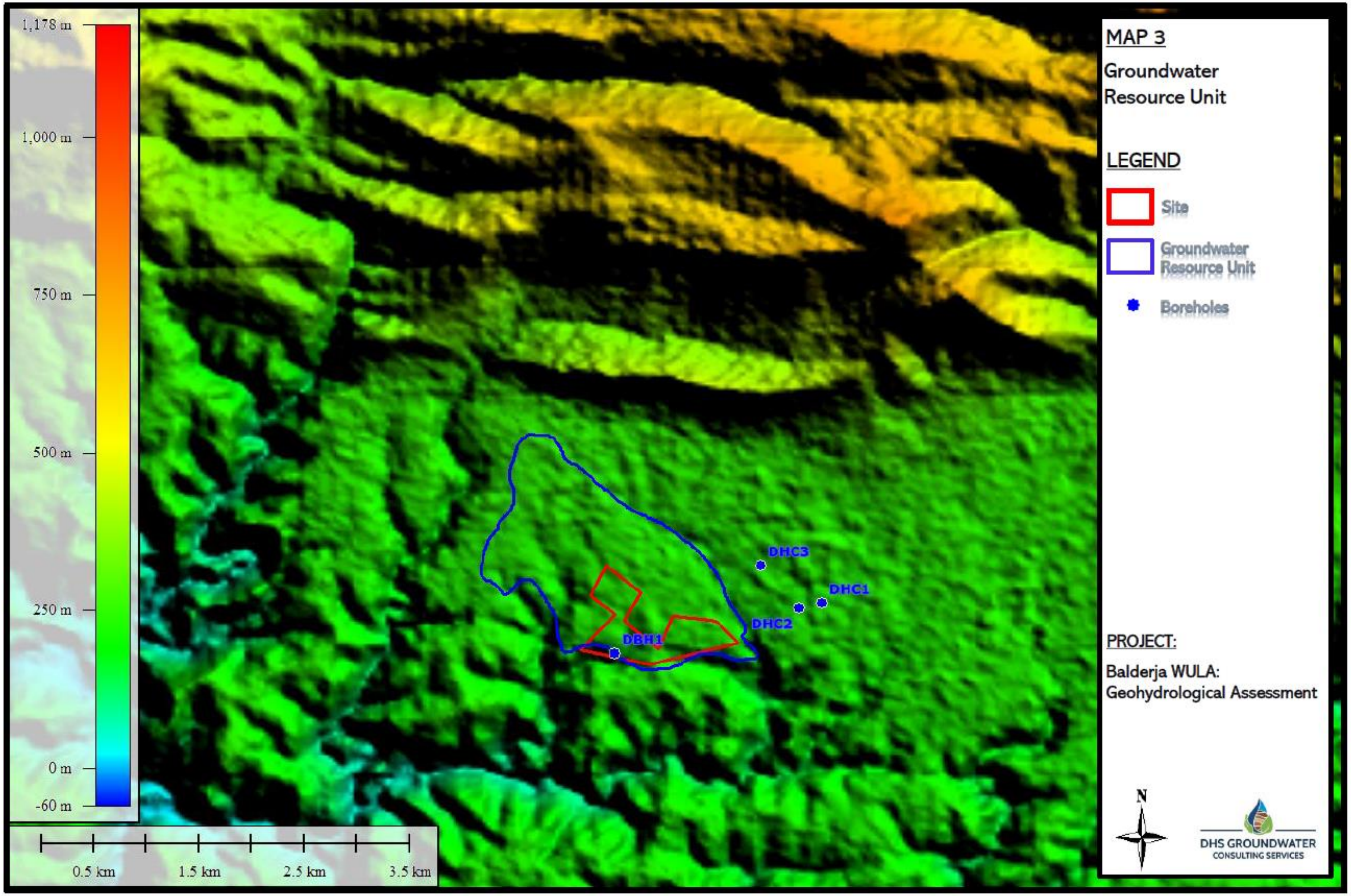
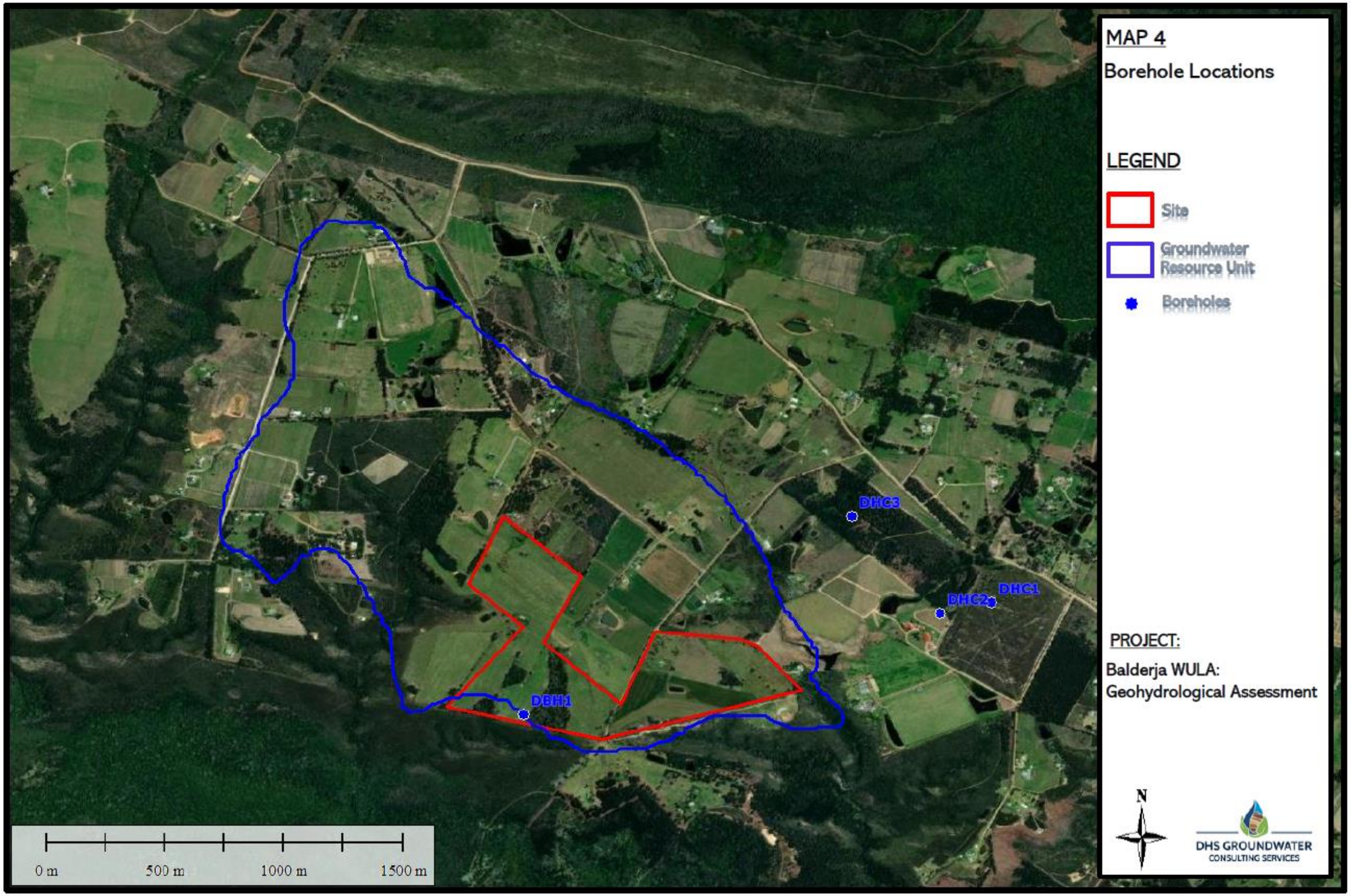
15 Appendices

15.1 Appendix 1: Maps




MAP 2
Geological Setting
LEGEND
Site
Groundwater Resource Unit
Op: Peninsula Formation (Quartzitic Sandstone)
Sk: Skurweberg Formation (Quartzitic Sandstone)
St: Goudini Formation (Quartzitic Sandstone)
PROJECT:
Balderja WULA: Geohydrological Assessment
0.5 km
1.5 km
2.5 km
3.5 km
4.5 km
N
DHS GROUNDWATER CONSULTING SERVICES


1,178 m
1,000 m
750 m
500 m
250 m
0 m
-60 m
0.5 km
1.5 km
2.5 km
3.5 km
DHC3
DHC1
DHC2
DBH1
MAP 3
Groundwater Resource Unit
LEGEND
Site
Groundwater Resource Unit
Boreholes
PROJECT:
Balderja WULA: Geohydrological Assessment
N
DHS GROUNDWATER CONSULTING SERVICES


MAP 4
Borehole Locations
LEGEND
Site
Groundwater Resource Unit
Boreholes
PROJECT:
Balderja WULA:
Geohydrological Assessment
DHC3
DHC2
DHC1
DBH1
0 m
500 m
1000 m
1500 m
N
DHS GROUNDWATER CONSULTING SERVICES

15.2 Appendix 2: DWS Guidelines for Water Use Licence Applications

ANNEXURE B

REQUIREMENTS FOR WATER USE LICENCE APPLICATION: GROUNDWATER ABSTRACTION [S 21 (a)]

The *Initial Regional* assessment is needed to determine the amount of information necessary for each new Water Use licence application for abstraction from groundwater, based on the amount of recharge that is used by the applicant in relation to the specified property.

Categories A, B and C list the information requirements for the licence application, as should be provided by the applicant to the Department of Water Affairs & Forestry.

Regional - Initial

- Size of property ($AREA_{PROP}$)
- Recharge - HP (RE)
- Existing use volume (ABS_{EX})
- New use volume (ABS_{NEW})
- Scale of abstractions (ABS_{SCALE})

CALCULATION

$AREA_{PROP} * RE = RE_{AREA}$ (m^3/a)

$ABS_{EX} + ABS_{NEW} = ABS_{TOTAL}$ (m^3/a)

$ABS_{SCALE} = (ABS_{TOTAL} / RE_{AREA}) * 100$

<u>Please note:</u> The calculation above should be done for each proposed abstraction point (borehole), with the value of "$AREA_{PROP}$" being the area of the relevant aquifer within the property boundaries. The highest value for the relevant property should then be used to calculate the % of recharge as categorized below.

Small scale abstractions (<60% recharge on property)	**Category A**
Medium scale abstractions (60-100% recharge on property)	**Category B**
Large scale abstractions (>100% of recharge on property)	**Category C**

The Regional RDM support is info that should be submitted with the request for a Reserve determination. This will not only speed up the process, but also render more confidence to the Reserve determination.

Regional - RDM support

- Delineate resource units (default quaternary, unless geologically different)
- Delineate response units (same as resource unless existing information shows otherwise)
- Drainage (rivers and gauging stations in the resource unit area)
- Climate (average rainfall, reference source)
- Vegter regions (hydrological regions and recharge)
- Geo-hydrology - wq, wl, aquifer tests, main fracture zones – storage, sustainable yield, assurance of supply?
- Aquifer status: Local expert consideration (reference source), natural / impacted (mapping these areas in the resource unit), importance (both socio-economic and strategic), vulnerability, dependent ecosystems, total current use, classification (Parsons and current resource classification system).
- Licensing conditions - wl, wq, level of acceptable degradation?
- Monitoring requirements - according to the Category.
- Site visit necessary to validate all info - regional and applicant

2

Category A

- Volume and purpose of the water required.
- Detail borehole census on the property in question. Information to be collected should include pump depth / borehole depth, depth to water level, yield of the borehole, volume abstracted (daily, weekly, monthly).
- Proximity to surface water discharges (springs, seeps, wetlands streams, rivers, lakes) and groundwater dependant ecosystems.
- Geo-referenced map of the property in question, with boreholes, physical structures (houses, stores, irrigation equipment) and current pollution sources (septic tanks, pit latrines, petrol/diesel tanks, irrigation areas) depicted.
- Monitoring programme - monthly water levels, monthly rainfall.

Category B

- Geology of the area / borehole?
- Volume and purpose of the water required.
- Detail borehole census within a 1km width zone around the property in question as well as on the property itself. Information to be collected should at least include pump installation/ borehole depth, depth to water level, yield of the borehole, volume abstracted (daily, weekly, monthly), water quality (one macro analysis per property).
- Proximity to surface water discharges (springs, seeps, wetlands streams, rivers, lakes) and groundwater dependant ecosystems.
- Geo-referenced map of the property in question, with boreholes, surface water features, physical structures (houses, stores, irrigation equipment) and current pollution sources (septic tanks, pit latrines, petrol/ diesel tanks irrigation areas) depicted.
- Contact details of relevant parties in the hydro census area.
- Potential impacts of potential use on groundwater and surface water quality.
- Monitoring programme - weekly water levels, weekly rainfall, 6 monthly macro analysis and surface water discharges in the 1km width zone.

Category C

- A geo-hydrological report compiled by an acceptable and qualified geo-hydrological consultant. Report should include appropriate maps, tables and figures to support the conclusions and recommendations.
- Detail geology of the area, including structures, maps etc.
- Detail borehole census within at least 1km width zone around the area of recharge as well as on the area itself. Information to be collected for each borehole should at least include pump installation depth, borehole depth, depth of water level, yield of the borehole, depth of water strike(s), volume abstracted (daily, weekly, monthly) and water quality (one macro analysis per property in the zone).
- Aquifer description and characteristics including extent of the aquifer and hydraulic properties (storativity and transmissivity). This would require testing. Drilling might or might not be required. Groundwater piezometric contour map showing flow direction and a depth to water level contour map.

3

- Effective annual recharge on this property and the safe yield of the aquifer.
- Volume and purpose of the water required and the volume available for abstraction. A water balance that at least cover the aquifer unit in which the property is located should, in other words, is done that includes all gains and losses.
- Contact details of relevant parties in the hydro census area.
- Impact the abstraction will have on existing users and surrounding properties. This should be short- and long-term impact. This might have to be supported by a numerical model.
- Proximity to and potential impact of the abstraction on surface water discharges and groundwater dependant terrestrial ecosystems.
- Potential impact of potential use on groundwater and surface water quality.
- Geo-referenced map of the property in question, with boreholes, surface water features, geological features, physical structures (houses, stores, irrigation equipment) and current pollution sources (septic tanks, pit latrines, petrol/ diesel tanks, irrigation areas) depicted.
- Monitoring programme - weekly water levels, weekly rainfall, 3 monthly macro analysis and surface water discharges and 6 monthly qualities in the 1km width zone.

The Department of Water Affairs and Forestry recommends that the following measures be taken when testing bore holes for sustainable yields and to provide the following information:

- Refer to test procedures in the South African National Standards Code No.: SANS 10299.
- Perform a three (3) hour stepped draw down test to determine the discharge rate of the intended constant rate test OR;
- The constant discharge test should be done at approximately $^2/_3$ of the blow yield of the bore hole.
- For **HOUSEHOLD** use it as recommended that a 8 hour constant rate test be performed with the draw down and the recovery measured.
- For **IRRIGATION** it as recommended that a 24 constant rate test should be performed while the draw down and the recovery is measured. This test could also be performed for intended **BULK WATER SUPPLY** for a volume of up to 150 000 m^3 per annum.
- For **BULK WATER SUPPLY** in excess of 150 000 m^3 per annum it as recommended that a 72 hour constant rate test should be performed while the draw down and the recovery of the bore hole is measured.
- All data as obtained above should be attached to the relevant Water Use License Application forms, together with an analysis of the data (including draw down curves) and recommendation for the sustainable yield of the borehole(s), by a qualified Geo-hydrologist .

NOTE: The above-recommended requirements may change without prior notice as required by DWAF to effectively manage the respective water resource.

15.3 Appendix 3: Impact Assessment Methodology

METHODOLOGY FOR THE ASSESSMENT OF IMPACTS

The assessment of the predicted significance of impacts for a proposed development is by its nature, inherently uncertain – environmental assessment is thus an imprecise science. To deal with such uncertainty in a comparable manner, a standardised and internationally recognised methodology has been developed. This methodology will be applied in this study to assess the significance of the potential environmental impacts of the proposed development.

For each predicted impact, certain criteria are applied to establish the likely **significance** of the impact, firstly in the case of no mitigation being applied and then with the most effective mitigation measure(s) in place.

These criteria include the **intensity** *(*size or degree scale), which also includes the **type** of impact, being either a positive or negative impact; the **duration** (temporal scale); and the **extent** (spatial scale). For each predicted impact, the specialist applies professional judgement in ascribing a numerical rating for each of these criteria respectively as per Table 1, Table 2 and Table 3 below. These numerical ratings are used in an equation whereby the **consequence** of the impact can be calculated. Consequence is calculated as follows:

Consequence = type x (intensity + duration + extent)

Depending on the numerical result, the impact's consequence would be defined as either extremely, highly, moderately or slightly detrimental; or neutral; or slightly, moderately, highly or extremely beneficial. These categories are provided in Table 5 and Table 6.

To calculate the significance of an impact, the **probability** (or likelihood) of that impact occurring is also taken into account. The most suitable numerical rating for probability is selected from Table 4 below and applied with the consequence as per the equation below:

Significance = consequence x probability

Depending on the numerical result, the impact would fall into a significance category as negligible, minor, moderate or major, and the type would be either positive or negative. These categories are provided in Table 6.

Once the significance of an impact occurring without mitigation has been calculated, the specialist must also apply their professional judgement to assign ratings for the same impact after the proposed mitigation has been implemented.

The tables on the following pages show the scales used to classify the above variables, and define each of the rating categories.

Table 1 | Definition of Intensity ratings

Rating	Criteria	
	Negative impacts (Type of impact = -1)	**Positive impacts** (Type of impact = +1)
7	Irreparable damage to biophysical and / or social systems. Irreplaceable loss of species.	Noticeable, on-going benefits to which have improved the quality and extent of biophysical and / or social systems, including fomal protection.
6	Irreparable damage to biophysical and / or social systems and the contravention of legislated standards.	Great improvement to ecosystem processes and services.
5	Very serious impacts and irreparable damage to components of biophysical and / or social systems.	On-going and widespread positive benefits to biophysical and / or social systems.
4	On-going damage to biophysical and / or social system components and species.	Average to intense positive benefits for biophysical and / or social systems.
3	Damage to biophysical and / or social system components and species.	Average, on-going positive benefits for biophysical and / or social systems.
2	Minor damage to biophysical and / or social system components and species. Likely to recover over time. Ecosystem processes not affected.	Low positive impacts on biophysical and / or social systems.
1	Negligible damage to individual components of biophysical and / or social systems.	Some low-level benefits to degraded biophysical and / or social systems.

*NOTE: Where applicable, the intensity of the impact is related to a relevant standard or threshold, or is based on specialist knowledge and understanding of that particular field.

Table 2 | Definition of Duration ratings

Rating	Criteria
7	**Permanent:** The impact will remain long after the life of the project
6	**Beyond project life:** The impact will remain for some time after the life of the project
5	**Project Life:** The impact will cease after the operational life span of the project
4	**Long term:** 6-15 years
3	**Medium term:** 1-5 years
2	**Short term:** Less than 1 year
1	**Immediate:** Less than 1 month

Table 3 | Definition of Extent ratings

Rating	Criteria
7	**International:** The effect will occur across international borders
6	**National:** Will affect the entire country
5	**Province/ Region:** Will affect the entire province or region
4	**Municipal Area:** Will affect the whole municipal area
3	**Local:** Extending across the site and to nearby settlements
2	**Limited:** Limited to the site and its immediate surroundings
1	**Very limited:** Limited to specific isolated parts of the site

Table 4 | Definition of Probability ratings

Rating	Criteria
7	**Certain/ Definite:** There are sound scientific reasons to expect that the impact will definitely occur
6	**Almost certain/Highly probable:** It is most likely that the impact will occur
5	**Likely:** The impact may occur
4	**Probable:** Has occurred here or elsewhere and could therefore occur
3	**Unlikely:** Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
2	**Rare/ improbable:** Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the project but has happened elsewhere. The possibility of the impact manifesting is very low as a result of design, historic experience or implementation of adequate mitigation measures
1	**Highly unlikely/None:** Expected never to happen.

Table 5 | Application of Consequence ratings

Range		Significance rating
-21	-18	Extremely detrimental
-17	-14	Highly detrimental
-13	-10	Moderately detrimental
-9	-6	Slightly detrimental
-5	5	Negligible
6	9	Slightly beneficial
10	13	Moderately beneficial
14	17	Highly beneficial
18	21	Extremely beneficial

Table 6 | Application of significance ratings

Range		Significance rating
-147	-109	Major - negative
-108	-73	Moderate - negative
-72	-36	Minor - negative
-35	-1	Negligible - negative
0	0	Neutral
1	35	Negligible - positive
36	72	Minor - positive
73	108	Moderate - positive
109	147	Major - positive

Despite attempts at providing a completely objective and impartial assessment of the environmental implications of development activities, environmental assessment processes can never escape the subjectivity inherent in attempting to define significance. The determination of the significance of an impact depends on both the context (spatial scale and temporal duration) and intensity of that impact. Since the rationalisation of context and intensity will ultimately be prejudiced by the observer, there can be no wholly objective measure by which to judge the components of significance, let alone how they are integrated into a single comparable measure.

This notwithstanding, in order to facilitate informed decision-making, environmental assessments must endeavour to come to terms with the significance of the potential environmental impacts associated with particular development activities. Recognising this, Geovation has attempted to address potential subjectivity in the current EIA process as follows:

- Being explicit about the difficulty of being completely objective in the determination of significance, as outlined above;
- Developing an explicit methodology for assigning significance to impacts and outlining this methodology in detail. Having an explicit methodology not only forces the specialist to come to terms with the various facets contributing towards the determination of significance, thereby avoiding arbitrary assignment, but also provides the reader with a clear summary of how the specialist derived the assigned significance;
- Wherever possible, differentiating between the likely significance of potential environmental impacts as experienced by the various affected parties; and
- Utilising a team approach and internal review of the assessment to facilitate a more rigorous and defendable system.

Although these measures may not totally eliminate subjectivity, they provide an explicit context within which to review the assessment of impacts.

15.4 Appendix 4: Pumptesting Data Sheets

Scenic route 585 t/a Welltek Services
Vat nr: 46802 64720
Email: welltekservices@gmail.com

Welltek services
Borehole testing and associated projects

CC Registration nr: 2005/137482/23
18 Highfield Road, EAST LONDON, 5205
Cell: +27 (0)71 031 5088
Fax: +27 (0)88 517 8242

BOREHOLE TEST RECORD

Borehole Number:	DBH 1	Province:	WESTERN CAPE
Alternative Number:		District:	CRAGS
Coordinates: Latitude [°S]	33.950830	Town/Village/Farm:	DENINA
Longitude [°E]	23.444360	Rig Type & number:	ISUZU
Date & Time Test Started:	8/27/2021 0:00	Operator:	PETER
Date & Time Test Ended:	9/4/2027 0:00	Supervisor:	HERMAN
Consultant:	DHS		
CONSULTANT - DATA PROVIDED / INSTRUCTIONS:		**EXISTING INSTALLATION:**	
Borehole depth [mbgl]:		Diesel/Electric/Wind/Hand	N/A
Blow Yield [l/s]:		Pump Make & Serial no:	N/A
Water Strike Depth(s) [mbgl]:		Intallation Depth (m)	N/A
Installation depth [mbgl]:		Type & Condition - Pump:	N/A
Estimated Steps [l/s] - Step 1:		- Column:	N/A
Step 2:		- Pump House	N/A
Step 3:		**FIELD MEASUREMENTS:**	
Step 4:		Depth Before Test [mbcl]:	250.00
Step 5:		Depth after Test [mbcl]:	250.00
Step 6:		Water Level before Test [mbcl]:	87.03
Step Duration [min]:		Water Level after Test [mbcl]:	87.03
Step Recovery Duration [Hrs]:		Casing Depth [mbcl]:	PVC
Constant Yield [l/s]:		Casing Height [magl]:	0.26
Constant Duration [Hrs]:		Casing Diameter [mm]:	186.00
Recovery Duration [Hrs] / Drawdown %:		**TEST PUMP INSTALLATION DETAILS:**	
Lenghth of Layflat Required [m]:		Pump Used:	BP 40
Frequency of pH and EC Measurements:		Depth Installed [mbcl]:	180.00
SAMPLE INSTRUCTIONS:		Datum Level above Casing [m]:	0.48
		Length of Layflat [m]:	50.00

GENERAL ACTIONS:

Supplied new steel cover [Yes/No]:	NO	Slug Test [Yes/No]:	N/A
Welded existing steel cover back on [Y/N]:	YES	Re-install existing pump [Yes/No]:	N/A
Borehole Marking [Yes/No]:	NO	If not, where was it stored?	N/A
Site Cleaning and Finishing [Yes/No]:	YES	Maintenance work [Hrs]:	N/A
Data Reporting and Recording [Yes/No]:	YES	Maintenance Travel [km]:	N/A
Digital Photo Taken? [Yes/No]	NO	List of parts replaced/repaired:	N/A
RETREAT FROM SITE		Date &Time Sampled:	SAMPLE TAKEN BY CONSULTANT

It is hereby acknowledged that upon leaving the site, all existing equipment is in an acceptable condition.

NAME:	
DESIGNATION:	
SIGNATURE:	
DATE:	

COMMENTS BY ONSITE CREW

WELLTEK SERVICES - Borehole testing and associated projects

BOREHOLE NO:	DBH 1	WATER LEVEL [mbdl]:	37.51	WATER DEPTH [mbgl]:	36.77	AVAILABLE DRAWDOWN [m]:	92.97

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE & TIME		8/30/2021 12:00			DATE & TIME		8/30/2021 13:00			DATE & TIME		8/30/2021 14:00		
TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)	TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)	TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1	0.53		1		1	2.94		1		1	6.62		1	
2	0.76		2		2	3.07		2		2	8.56		2	
3	0.94		3		3	3.12	1.14	3		3	9.29	3.02	3	
5	1.13		5		5	3.28		5		5	13.78		5	
7	1.23		7		7	3.35		7		7	15.07		7	
10	1.46	0.52	10		10	3.44	1.13	10		10	16.08	3.04	10	
15	1.77		15		15	3.58		15		15	18.27		15	
20	2.03		20		20	3.65		20		20	20.44		20	
30	2.29	0.53	30		30	3.77	1.14	30		30	23.84		30	
40	2.38		40		40	3.85		40		40	25.13		40	
50	2.59	0.52	50		50	3.94	1.15	50		50	27.84	3.03	50	
60	2.62		60		60	4.08		60		60	29.44		60	
			70					70					70	
			80					80					80	
			90					90					90	
			100					100					100	
			110					110					110	
			120					120					120	
			150					150					150	
	Average Yield (l/s):	0.52	180			Average Yield (l/s):	1.14	180			Average Yield (l/s):	3.03	180	
	Drawdown (%):	2.82	210			Drawdown (%):	4.39	210			Drawdown (%):	31.67	210	
DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE & TIME		8/30/2021 15:00			DATE & TIME		8/30/2021 15:00			DATE & TIME		8/30/2021 15:00		
TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)	TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)	TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1	34.88		1		1			1		1			1	74.53
2	39.26		2		2			2		2			2	68.24
3	44.72	5.09	3		3			3		3			3	64.39
5	48.95		5		5			5		5			5	57.22
7	53.26		7		7			7		7			7	53.10
10	57.74	5.07	10		10			10		10			10	47.17
15	62.84		15		15			15		15			15	33.09
20	66.82		20		20			20		20			20	20.83
30	71.58		30		30			30		30			30	14.31
40	82.08	5.06	40		40			40		40			40	10.23
50	89.56		50		50			50		50			50	7.89
60			60		60			60		60			60	4.22
			70					70					70	2.83
			80					80					80	2.46
			90					90					90	2.09
			100					100					100	1.77
			110					110					110	1.59
			120					120					120	1.34
			150					150					150	1.17
			180					180					180	0.93
			210					210					210	0.71
			240					240					240	0.59
	Average Yield (l/s):	5.06	300			Average Yield (l/s):	0.00	300			Average Yield (l/s):	0.00	300	0.27
	Drawdown (%):	96.33	360			Drawdown (%):		360			Drawdown (%):		360	0.11

DATUM LEVEL ABOVE GROUND [m]: 0.74 — WAS SAND PUMPED ? NO

STATIC WATER LEVEL AFTER STEPPED DISCHARGE TEST [mbdl]: 37.51 — WAS THE WATER CLEAN? YES

STEPPED DRAWDOWN SUMMARY

STEP	DURATION [min]	DRAWDOWN [m]	DRAWDOWN [%]	AVERAGE YIELD [l/s]	RECOVERY [min]	RECOVERY [m]	RECOVERY [%]	STEP	DURATION [min]	DRAWDOWN [m]	DRAWDOWN [%]	AVERAGE YIELD [l/s]	RECOVERY [min]	RECOVERY [m]	RECOVERY [%]
1	60	2.62	2.82	0.52				5		0.00		0.00			
2	60	4.08	4.39	1.14				6		0.00		0.00			
3	60	29.44	31.67	3.03				7							
4	60	89.56	96.33	5.06				8							
DATE & TIME END:		8/30/2021 16:00						TOTAL:	240.00	89.56	96.33		0	0.00	0.00

COMMENTS:

ESTABLISHMENT						ESTABLISHMENT DATE:	2021/08/27
SITE MOVE FROM:	BOREHOLE: 0	VILLAGE: 0	MOVE TO:	BOREHOLE: DBH 1	VILLAGE: DENINA	DISTANCE BETWEEN BOREHOLES [km]	392.00

BOREHOLE NO:	DBH 1	WATER LEVEL [mbdl]:	87.51	WATER LEVEL [mbgl]:	86.77

CONSTANT DISCHARGE TEST & RECOVERY

DISCHARGE BOREHOLE		OBSERVATION HOLE 1		OBSERVATION HOLE 2		OBSERVATION HOLE 3	
TEST STARTED		WATER LEVEL [mbcl]:	N/A	WATER LEVEL [mbcl]:	N/A	WATER LEVEL [mbcl]:	N/A
DATE & TIME:	8/31/2021 7:00	CASING HEIGHT [m]:	N/A	CASING HEIGHT [m]:	N/A	CASING HEIGHT [m]:	N/A
TEST COMPLETED		CASING DIAMETER [m]:	N/A	CASING DIAMETER [m]:	N/A	CASING DIAMETER [m]:	N/A
DATE & TIME:	9/4/2021 12:00	DISTANCE [m]:	N/A	DISTANCE [m]:	N/A	DISTANCE [m]:	N/A

TIME [min]	DRAWDOWN [m]	YIELD [l/s]	TIME [min]	RECOVERY [m]	TIME: [min]	DRAWDOWN [m]	RECOVERY [m]	TIME: [min]	DRAWDOWN [m]	RECOVERY [m]	TIME: [min]	DRAWDOWN [m]	RECOVERY [m]
1	1.64		1	75.66	1			1			1		
2	3.32		2	59.34	2			2			2		
3	5.13	1.24	3	51.45	3			3			3		
5	6.81		5	46.87	5			5			5		
7	8.07	3.09	7	39.47	7			7			7		
10	11.34		10	25.01	10			10			10		
15	13.73		15	21.77	15			15			15		
20	15.41		20	15.23	20			20			20		
30	16.57	3.08	30	12.44	30			30			30		
40	18.94		40	11.17	40			40			40		
60	20.97		60	10.66	60			60			60		
90	22.09	3.00	90	9.84	90			90			90		
120	22.99		120	9.30	120			120			120		
150	23.77		150	8.21	150			150			150		
180	24.41		180	7.69	180			180			180		
210	25.17	3.01	210	7.41	210			210			210		
240	26.04		240	7.07	240			240			240		
300	27.11	3.07	300	6.90	300			300			300		
360	27.81		360	6.74	360			360			360		
420	28.54		420	6.51	420			420			420		
480	29.16		480	6.36	480			480			480		
540	29.62		540	6.19	540			540			540		
600	30.17		600	5.66	600			600			600		
720	30.71	3.04	720	5.43	720			720			720		
840	30.94		840	5.27	840			840			840		
960	31.22		960	5.13	960			960			960		
1080	31.65		1080	4.99	1080			1080			1080		
1200	32.12		1200	4.52	1200			1200			1200		
1320	32.27	3.00	1320	4.11	1320			1320			1320		
1440	32.49		1440	3.62	1440			1440			1440		
1560	32.71		1560	3.37	1560			1560			1560		
1680	32.94		1680	3.14	1680			1680			1680		
1800	33.08	3.01	1800	2.81	1800			1800			1800		
1920	33.17		1920	2.59	1920			1920			1920		
2040	33.39		2040	2.21	2040			2040			2040		
2160	33.61	3.07	2160	1.82	2160			2160			2160		
2280	33.84		2280	1.49	2280			2280			2280		
2400	33.97		2400	1.10	2400			2400			2400		
2520	34.15		2520	0.79	2520			2520			2520		
2640	34.39		2640	0.62	2640			2640			2640		
2760	34.55	3.04	2760	0.47	2760			2760			2760		
2880	34.77		2880	0.35	2880			2880			2880		
2940	42.96	4.26			3000			3000			3000		
3000	53.69				3120			3120			3120		
3060	66.96	4.25			3240			3240			3240		
3120	79.86				3360			3360			3360		
3180	92.35	4.23			3480			3480			3480		
					3600			3600			3600		
					3720			3720			3720		
					3840			3840			3840		
					3960			3960			3960		
					4080			4080			4080		
					4200			4200			4200		
					4320			4320			4320		

DURATION TOTALS [min]	CDT:	3180	RECOVERY:	2880	OBS 1:	0	OBS 2:	0	OBS 3:	0
DRAWDOWN / RECOVERY [m]	CDT:	92.35	RECOVERY:	0.35	OBS 1:	0.00	OBS 2:	0.00	OBS 3:	0.00
DRAWDOWN / RECOVERY [%]	CDT:	99.33	RECOVERY:	99.62	OBS 1:	0.00	OBS 2:	0.00	OBS 3:	0.00
AVERAGE YIELD [l/s]	CDT:	3.63	COMMENTS:							

GENERAL ITEMS AND MAINTENANCE

TRAVELING FOR VERIFICATION [km]:		SAMPLE TRANSPORTATION [km]:		TRANSPORT EXISTING EQUIPMENT [km]:	

15.5 Appendix 5: Laboratory Reports

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WO 96606:119383

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Water

T0822

Nviro Business Hub unit 6, Ou Wapad road, Ifafi, Hartbeespoort, 0260 | Tel: 012 252 7588 | www.nviroteklabs.co.za

Datum Ontvang/Date Received:	2021-10-01	**Verslag nr./Report no.:**	WO 96606:119383
Datum Begin/Date Commenced:	2021-10-04	**Datum Gerapporteer/Date Reported:**	2021-10-12

To/Aan:	AGRI TECHNOVATION (PTY) LTD	**Representative/Verteenwoordiger:**	ERIK DE VRIES
		Farm Name/Plaas Naam:	
	27219757438	**Order/Bestel#:**	DENINA,AT-BF273
	P.O. BOX 5435 MEYERSDAL 1447	**Email:**	labresults@agritechnovation.co.za

Lab Nommer	Verwysing	Beskrywing	Ca	Mg	K	Na	SO4	H2PO4	Fe	Mn	Cu	Zn	B	NH4-N *	NO3-N *	pH	EC *	TDS *	Cl *	HCO3 *	CO3 *	Ca Hardness *
Lab Number	**Reference**	**Description**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**ug/l**	**ug/l**	**ug/l**	**ug/l**	**ug/l**	**mg/l**	**mg/l**	**pH units**	**mS/m**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l CaCO3**
W6-26329	AT-BF273	DBBH1	3.55	2.85	<10	39.48	6.03	<0.75	560.00	10.00	<20	343.90	22.10	<0.1	<0.01	6.0	26.90	172	67.86	16.00	0.00	8.88

Lab Nommer	Verwysing	Beskrywing	Mg Hardness *	Total Hardness *	Total Alkalinity *	SAR *	Class *
Lab Number	**Reference**	**Description**	**mg/l CaCO3**	**mg/l CaCO3**	**mg/l CaCO3**	**-**	**-**
W6-26329	AT-BF273	DBBH1	11.71	20.59	13.12	3.79	C2:S1

NOTAS / NOTES:

Verslag goedgekeur deur / Report approved by:

Courtney Johnson

courtney.johnson@nviroteklabs.co.za

TS: WIN 014, 041

NviroTek Labs

Verslag / Report

Water

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sanas Testing Laboratory T0822 ilac-MRA

BELANGRIK / IMPORTANT

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** Results marked with ** are Subcontracted Tests and are not included in the Schedule of Accreditation for this laboratory.

< Where a result is reported as less than (<) a value, the result obtained is below the limit of detection for the specific analyte.

1. This test report shall not be reproduced except in full, without written approval of the laboratory. These results are only applicable to the tests performed on the sample as received.
2. Results will be reported electronically in a PDF format. The Laboratory will not be responsible for any unauthorised changes made to results after the report was issued.
3. Uncertainties of Measurement, Limits of Detection and Method Descriptions will be provided upon request.
4. Decision Rule: Results reflecting on Test Reports are the actual results as obtained at the time of testing, and do not include any uncertainty considerations. NviroTek does not issue any statements of conformity, unless by prior arrangement.
5. Any opinions and interpretations expressed herein are outside the scope of accreditation for the laboratory.

Test	Method	Test	Method
Ca (Calcium)	WIN 041	pH (value at 25°C)	WIN 014
Mg (Magnesium)	WIN 041	EC (Conductivity) at 25°C*	WIN 033
K (Potassium)	WIN 041	Total Dissolved Solids (Calculated)*	CALCULATED
Na (Sodium)	WIN 041	Cl (Chloride)*	WIN 032
S (Sulphate) expressed as SO4	WIN 041	HCO3 (Bicarbonate)*	WIN 028
P as H2PO4	WIN 041	CO3 (Carbonate)*	WIN 028
Fe (Iron)	WIN 041	Ca Hardness*	CALCULATED
Mn (Manganese)	WIN 041	Mg Hardness*	CALCULATED
Cu (Copper)	WIN 041	Total Hardness*	CALCULATED
Zn (Zinc)	WIN 041	Total Alkalinity* (Sum of M & P alkalinity)	CALCULATED
B (Boron)	WIN 041	SAR - Sodium Absorption Ratio*	CALCULATED
NH4-N (Ammonia)*	WIN 048	Irrigation Class*	N/A
NO3-N (Nitrate)*	WIN 048		

End of Report

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Water

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Datum Ontvang/Date Received:	2021-03-19	**Verslag nr./Report no.:**	WO 86917:106895
Datum Begin/Date Commenced:	2021-03-19	**Datum Gerapporteer/Date Reported:**	2021-03-30

To/Aan:	AGRI TECHNOVATION (PTY) LTD	**Representative/Verteenwoordiger:**	ERIK DE VRIES
		Farm Name/Plaas Naam:	
	27219757438	**Order/Bestel#:**	Brenda Niehaus, AT-BF190
	P.O. BOX 5435 MEYERSDAL 1447	**Email:**	labresults@agritechnovation.co.za

Lab Nommer	Sample Reference	Ca	Mg	K	Na	SO4	H2PO4	Fe	Mn	Cu	Zn	B	NH4-N *	NO3-N *	pH	EC *	TDS *	Cl *	HCO3 *	CO3 *	Ca Hardness *	Mg Hardness *	Total Hardness *	Total Alkalinity *
Lab Number	**Monsterverwysing**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**ug/l**	**ug/l**	**ug/l**	**ug/l**	**ug/l**	**mg/l**	**mg/l**	**pH units**	**mS/m**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l CaCO3**	**mg/l CaCO3**	**mg/l CaCO3**	**mg/l CaCO3**
W6-23483	AT-BF190 BRBH1	34.96	47.30	11.62	312.59	26.46	<0.75	39060.00	1280.00	<20	814.50	34.20	<0.1	<0.01	5.9	211.00	1350	699.42	20.06	0.00	87.40	194.40	281.80	16.46

Lab Nommer	Sample Reference	SAR *	Class *
Lab Number	**Monsterverwysing**	**-**	**-**
W6-23483	AT-BF190 BRBH1	8.10	C3:S2

NOTAS / NOTES:

Verslag goedgekeur deur / Report approved by:

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TS: WIN 014, 041

FRM 176 version: 01, 2018-06-29

WO 86917:106895

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BELANGRIK / IMPORTANT

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1. This test report shall not be reproduced except in full, without written approval of the laboratory. These results are only applicable to the tests performed on the sample as received.
2. Results will be reported electronically in a PDF format. The Laboratory will not be responsible for any unauthorised changes made to results after the report was issued.
3. Uncertainties of Measurement, Limits of Detection and Method Descriptions will be provided upon request.
4. Decision Rule: Results reflecting on Test Reports are the actual results as obtained at the time of testing, and do not include any uncertainty considerations. NviroTek does not issue any statements of conformity, unless by prior arrangement.
5. Any opinions and interpretations expressed herein are outside the scope of accreditation for the laboratory.

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Mg (Magnesium)	WIN 041	EC (Conductivity) at 25°C*	WIN 033
K (Potassium)	WIN 041	Total Dissolved Solids (Calculated)*	CALCULATED
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S (Sulphate) expressed as SO4	WIN 041	HCO3 (Bicarbonate)*	WIN 028
P as H2PO4	WIN 041	CO3 (Carbonate)*	WIN 028
Fe (Iron)	WIN 041	Ca Hardness*	CALCULATED
Mn (Manganese)	WIN 041	Mg Hardness*	CALCULATED
Cu (Copper)	WIN 041	Total Hardness*	CALCULATED
Zn (Zinc)	WIN 041	Total Alkalinity* (Sum of M & P alkalinity)	CALCULATED
B (Boron)	WIN 041	SAR - Sodium Absorption Ratio*	CALCULATED
NH4-N (Ammonia)*	WIN 048	Irrigation Class*	N/A
NO3-N (Nitrate)*	WIN 048		

Klassifikasie van Besproeiingswater / Classification of Irrigation water

SAR: Due to the uncertainty of measurement for Calcium and Magnesium at very low levels, the SAR calculation will not be performed when the sum of Calcium and Magnesium is less than 0.5 mg/l. When evaluating this water sample for use on soil, the Sodium content should be considered carefully as Sodium in water at any level can negatively impact certain soils if Calcium and Magnesium is absent in the water source.

Klas / Class	EG / EC	Beskrywing / Description
C1	<25 mS/m	Baie goed / Very Good
C2	25 - 75 mS/m	Goed / Good
C3	75 - 225 mS/m	Sleg / Bad
C4	>225 mS/m	Baie Sleg / Very Bad

NAV / SAR	
S.1	Veilig op alle grondtipes / Safe on all soil types
S.2	Veilig op hoogs gestruktureerde gronde / Safe on High textured soils
S.3	Benodig gereelde gipstoediening / Needs regular gypsum addition
S.4	Gebruik vir besproeiing nie moontlik nie / Totally unsuitable for irrigation

Die optimale pH vir besproeiing is tussen 5.50 en 7.50
Die pH vir besproeiingswater in tonnels is 5.0 - 6.5
Die optimale EG vir algemene besproeiing is <100 mS/m en vir Hidropone is dit <50 mS/m
NAV <1 lewer geen probleme nie, NAV Tussen 1 en 3 het spesiale bestuur nodig.
Verwysing / Reference: US Agriculture Handbook 60 - Diagnosis and Improvement of Saline and Alkali Soils (Cert 2018-086)

The optimum pH for irrigation is between 5.50 and 7.50
The pH of water for irrigation of vegetables under protection is between 5.0 - 6.5
The optimal EC for irrigation is <100 mS/m and for Hydroponics it is <50 mS/m.
SAR < 1 presents no problem, but SAR between 1 and 3 needs special attention.

End of Report