WATER USE LICENCE APPLICATION

Geohydrological Assessment

12 October 2022

Prepared for:

Wisteria Boerdery (Pty) Ltd
PO Box 254
Patensie
6335
Contact: Mr R Du Preez
Cell: 083 330 7239
Email: deleen@wisteriafarm.co.za

by

DHS GROUNDWATER CONSULTING SERVICES

PROJECT TEAM

K Jeppesen

DH Stroebel

Report: DHS-22-192_W3

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Authors:

Keegan Jeppesen (MSc. Hydrogeology)
Hydrogeologist

Divan Stroebel (Pr.Sci.Nat, GWD, MGSSA, BSc Hons. Geology)
Hydrogeologist - Director
DHS Groundwater Consulting Services

DHS GROUNDWATER
CONSULTING SERVICES

9 Schubert Road
Walmer Heights
Port-Elizabeth
6070
South Africa

T +27 (0) 82 099 2366
E divan@dhsgroundwater.co.za
W https://dhsgroundwater.co.za

Main Authors Resume

Divan Stroebel is a SACNASP registered and active member of the Groundwater Division, the Geological Society of South Africa, hydrogeologist and professional geoscientist with more than 16 years of industry experience. He obtained his B.Sc. (Geology) degree in 2005 and his B.Sc. Honours (Geology) degree in 2006 from Stellenbosch University. From 2007, he worked throughout Africa as an exploration geologist in base metal, iron ore and gold exploration. In 2009 he joined a hydrogeological consultancy and completed additional groundwater modules at the Institute for Groundwater Studies (IGS), University of Free State. He was employed by mining giant, Rio Tinto in 2010 in Guinea as a Geologist, after which he was the Superintendent Geologist at Goldfields' Kloof mine from 2012. He joined AEON at the Nelson Mandela University (NMU) in 2014 as Associate Research Manager for the Karoo Shale Gas Research Programme- focused on Karoo hydrogeology.

Divan's technical experience includes all aspects of mineral exploration, extraction and reserve management as well as hydrogeological assessments, aquifer characterisation, groundwater supply development, groundwater and surface water characterisation and monitoring as well as water quality assessments.

Divan is very active in the hydrogeological community and has attended, presented at and co-organised numerous water-research workshops and conferences. In June 2016, he was appointed as a visiting researcher at Queen's University, Belfast. In China (2017), he successfully completed an international training programme on the Sustainable Development of Water Resources in Arid Regions for Developing Countries.

During his time at AEON, Divan researched the Groundwater Hydrochemistry and Aquifer Connectivity Baseline of the Eastern Cape Karoo. In anticipation of the controversial hydraulic fracturing planned for the Eastern Cape, he has obtained unique experience in the determination of salinity, aquifer yields and groundwater levels of the Karoo's scarce groundwater resources and has published an article in a special publication by the Geological Society of London on fractured aquifers on the topic. https://sp.lyellcollection.org/content/479/1/129

Divan is the founder and owner of DHS Groundwater Consulting Services and leads the team as principal hydrogeologist, overseeing all projects from inception to completion.

Declaration of Consultants Independence

I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);

• At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;

• Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;

• I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse any proposed developments, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;

• I do not have any influence over decisions made by the governing authorities;

• I undertake to disclose all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by a competent authority to such a relevant authority and the applicant;

• I have the necessary qualifications and guidance from professional experts in conducting specialist reports relevant to this application, including knowledge of the relevant Act, regulations and any guidelines that have relevance to the proposed activity;

• This document and all information contained herein is and will remain the intellectual property of DHS Groundwater Consulting (Pty) Ltd. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the specialist investigators.

• All the particulars furnished by me in this document are true and correct.

Divan Stroebel (Pr.Sci.Nat, GWD, MGSSA, B.Sc Hons. Geology)
Hydrogeologist
Director: DHS Groundwater Consulting Services (Pty) Ltd
SACNASP Registration Number 400371/12

DHS GROUNDWATER
CONSULTING SERVICES

9 Schubert Road
Walmer Heights
Port-Elizabeth
6070
South Africa

T +27 (0) 82 099 2366
E divan@dhsgroundwater.co.za
W https://dhsgroundwater.co.za

Executive Summary

Wisteria Boerdery (Pty) Ltd will be using groundwater for the irrigation of citrus orchards and other crops on the farms Klein Rivier 158 (Portion 40), hereafter also referred to as the site. Groundwater will be abstracted from a borehole with volumes exceeding General Authorisation (GA) and therefore the water use needs to be licensed. Wisteria Boerdery (Pty) Ltd therefore appointed DHS Groundwater Consulting Services (Pty) Ltd 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	Klein Rivier 158
Geology:	Enon and Kirkwood Formations of the Uitenhage Group. The Enon conglomerates are overlain by Kirkwood Formation mudstone and sandstone and both overlain by river gravel terraces. The regional scale Gamtoos fault (trending northwest-southeast) is located to the north of the site.
Aquifer Types:	Hard rock/Secondary fractured aquifers.
Aquifer Classification:	Major Aquifer System
Borehole Yield:	8.24 L/s
Depth to Water Table:	11.76 meters below ground level
Groundwater Quality:	Chloride, Sodium, Iron and Manganese do not comply with the (SANS 241-1:2015, edition 2) drinking water standards. TDS of 1100 mg/l.
Regional Groundwater Use:	Agriculture (Irrigation & stock watering)
Mean Annual Rainfall:	571 mm/a
Recharge:	25 - 37 mm/a (4.4% - 6.5% of MAP)
Groundwater available for abstraction from GRU:	0.240 Mm^3/a

Geohydrological Characteristics	Klein Rivier 158
Cumulative sustainable yield from tested borehole(s):	0.260 Mm^3/a
Recommended volume to be applied for:	0.216 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 0.216 Mm^3/annum which places the application in Category B (medium scale abstractions 60-100% recharge to the GRU). The tested borehole will be able to supply 100% of the recommended volume applied for.

From a water quality point of view, elevated Chloride, Sodium, Iron and Manganese exceeding SANS241 drinking water limits were reported in the borehole located within the site as well as in the two boreholes located outside the site sampled during the hydrocensus. One of the boreholes outside the site also has EC and TDS levels which exceed SANS241 drinking water limits and as such is not fit for human consumption.

It is the assessor's professional opinion that adequate information was available to appropriately assess the impact of groundwater abstraction from the production borehole 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.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

Term	Definition
%	Percentage
CDT	Constant Discharge Test
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
m^3	Cubic Meters

Term	Definition
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 Litre/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

Wisteria Boerdery (Pty) Ltd will be using groundwater for the irrigation of citrus orchards and other crops on the farms Klein Rivier 158 (Portion 40), hereafter also referred to as the site. Groundwater will be abstracted from a borehole with volumes exceeding General Authorisation (GA) and therefore the water use needs to be licensed. Wisteria Boerdery (Pty) Ltd therefore appointed DHS Groundwater Consulting Services (Pty) Ltd to conduct a geohydrological assessment as part of the Water Use License Application (WULA).

1.1 Site Location

The site is located on Klein Rivier 158, located approximately 2.6km north-east of the town of Hankey, within the Eastern Cape Province. It covers an area of approximately 60.85 ha (Map 1, Appendix A).

1.2 Topography and Drainage

The site is located in quaternary catchment L90B within the Mzimvubu to Tsitsikamma Water Management Area (WMA). The site is drained by the Klein Rivier flowing in a south easterly direction. The topography on site can be described as follow:

- The northern portion of the site drains in a southern direction towards the Klein Rivier. The highest point of the water divide being ~168 mamsl.
- The western portion of the site drains in an easternly direction towards the Klein Rivier. The highest point of the water divide being ~176 mamsl.
- The eastern portion of the site drains in a westerly direction towards the Klein Rivier. The highest point of the water divide being ~169 mamsl.
- Once the drainage has reached the lowest point within the central portion of the site (~23 mamsl), the site drains in a south easterly direction towards the Gamtoos River.

1.3 Climate

The weather is mild without extreme conditions with an average summer temperature of 21.8°C and a winter temperature of 14.03°C. The autumn months of March, April and May receive the lowest average windspeed of 10.49 km/h while the spring months of September, October and November receive the highest average windspeed of 12.08 km/h.

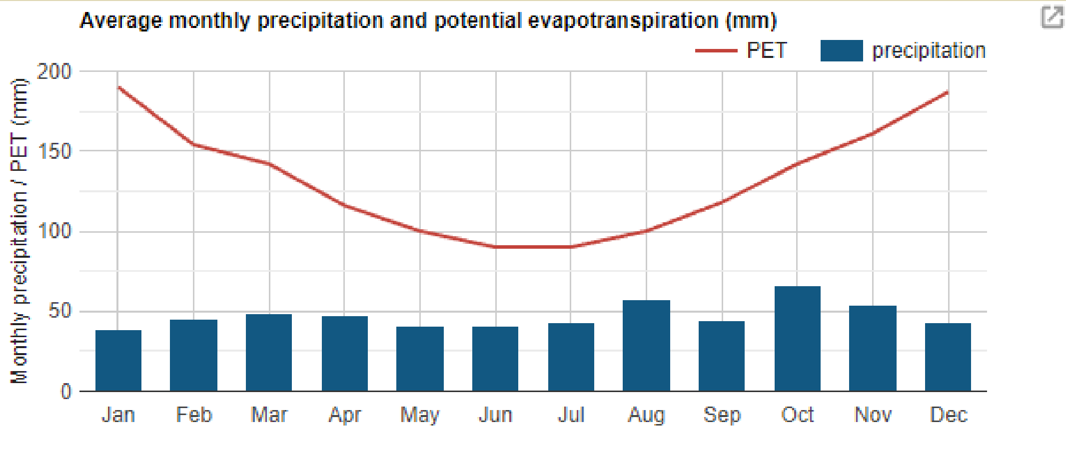
Meteorological data obtained from SamSam Water Climate Tool[1] is presented in Figure 1. Figures of 571 mm for the mean annual precipitation (MAP) and 1598 mm for the mean annual evaporation (MAE) is reported. The MAE exceeds the MAP by an order of magnitude, resulting in a negative moisture index. Rainfall 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

SamSamWater Climate Tool

Latitude, longitude: -33.8160, 24.9001

The average annual rainfall (1970-2000) for this location is 571 mm per year.
Average monthly rainfall and potential evapotranspiration (PET) values are displayed in the chart and table below.



description	PET	precipitation
01 - January	190	39
02 - February	154	45
03 - March	142	49
04 - April	116	48
05 - May	100	41
06 - June	90	41
07 - July	90	43
08 - August	100	58
09 - September	118	44
10 - October	142	66
11 - November	161	54
12 - December	187	43
Total	1,598	571

To copy the data for use in other software: click on the icon in the top-right corner of the table to open in a new tab. There you can select and copy the values.

Close

The data in this tool is sourced from WorldClim v2 and Global Aridity Index and Potential Evapotranspiration (ET0) Climate Database v2 . For questions or remarks on the data, please contact these organisations.

Figure 1. Precipitation and Evapotranspiration within the project area

2 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 borehole in terms of yield and quality;
- Complete an assessment of the groundwater use in the area by means of a hydrocensus within the Groundwater Resource Unit as a minimum, 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.

3 Methodology

It must be stated that no intrusive groundwater investigations (other than test pumping, groundwater level recording and sampling in existing borehole(s)) were done and reporting is thus based on and limited to observations made during the site visit, test pumping, hydrocensus and the collation of available information. The work completed for the purposes of compiling a geohydrological report comprised the following:

3.1 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.

3.2 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 as a minimum, up to a maximum distance of a 1km radius 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

3.3 Test Pumping

A seventy-two-hour constant discharge test followed by recovery monitoring was conducted on the proposed 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 a SANAS accredited laboratory for the analysis of the major ions and trace elements.

3.4 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".*

3.5 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.

3.6 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.

3.7 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].

[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.

3.8 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]"*.

4 Regional and Local Geology

Based on the 1:250 000 Geological Series (3324 Port Elizabeth[11]) the site is underlain by the Enon and Kirkwood Formations of the Uitenhage Group (Map 2, Appendix A). The Enon conglomerates are overlain by Kirkwood formation mudstone and sandstone and both overlain by river gravel terraces.

The lithostratigraphy is shown in Table 1.

Table 1. Lithostratigraphy of underlying geology

Group	Formation	Lithology
Uitenhage	Kirkwood (J-Kk)	Reddish & Greenish Mudstone, Sandstone.
	Enon (Je)	Conglomerate, subordinate Sandstone, Mudstone.
Quaternary		Alluvial & Fluvial sheet gravel and sand.

[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 (3324 Port Elizabeth). Geological Survey, 1986.

5 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 give rise to discrete zones of secondary permeability.

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

5.1 Aquifer Types and Borehole Yields

The study area is underlain by both a shallow primary alluvial aquifer along the floodplain of the Klein Rivier and a deeper secondary fractured rock aquifer occurring within the conglomerates and sandstone of the Enon- and Kirkwood Formation.

The Uitenhage beds are described as a dense mass of rock with low permeability and limited groundwater potential. A borehole yield analysis indicates that close to 40% of successful boreholes yield less than 0.5 l/s. This does not account for unsuccessful boreholes which were destroyed or backfilled, which makes the success rate even worse.

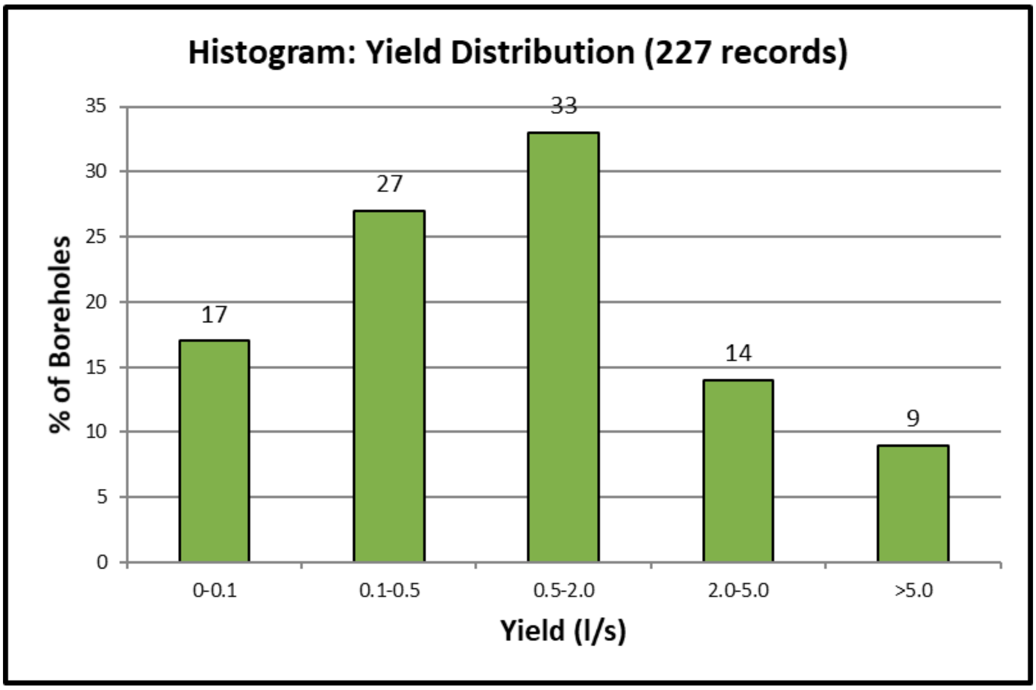


Figure 2. Yield Frequencies of borehole in the Uitenhage Group

Higher borehole yields are not uncommon, with yields of 2-5 l/s and >5 l/s (14% and 9% of borehole yields on record respectively) being reported, but this is not the norm.

---

[12] 1:500 000 General Hydrogeological Map, Port Elizabeth 3324 (1998)

[13] MEYER, P S (1998). An explanation of the 1:500 000 General Hydrogeological Map Port Elizabeth 3324. Department of Water Affairs and Forestry, Pretoria.

Based on the 1:500 000 Hydrogeological Map, the primary alluvial aquifers within the buried gravel terraces of the Klein Rivier have a yield potential of 0.5-2.0 l/s, while the yield potential of the fractured rock aquifer within the Enon conglomerates and Kirkwood sandstone is reported to be as low as 0 – 0.1 l/s.

5.2 Depth to Groundwater

The static groundwater level generally occurs between 21 and 30m below surface[14].

5.3 Groundwater Recharge and Baseflow

The study area falls within quaternary catchment L90B. 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):	571
Annual Recharge (mm):	25 – 37
Percentage Recharge of MAP:	4.4% - 6.5%
Annual Baseflow (mm):	10 – 25
Percentage Baseflow of MAP:	1.7% - 4.4%

5.4 Groundwater Quality

Groundwater with Electrical Conductivity (EC) readings in the range of 150-370 mS/m is common. Sodium, calcium, magnesium, chloride and, occasionally sulphate often exceed maximum permissible drinking water limits (SANS 241-1:2015).

5.5 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)

[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.

- 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.

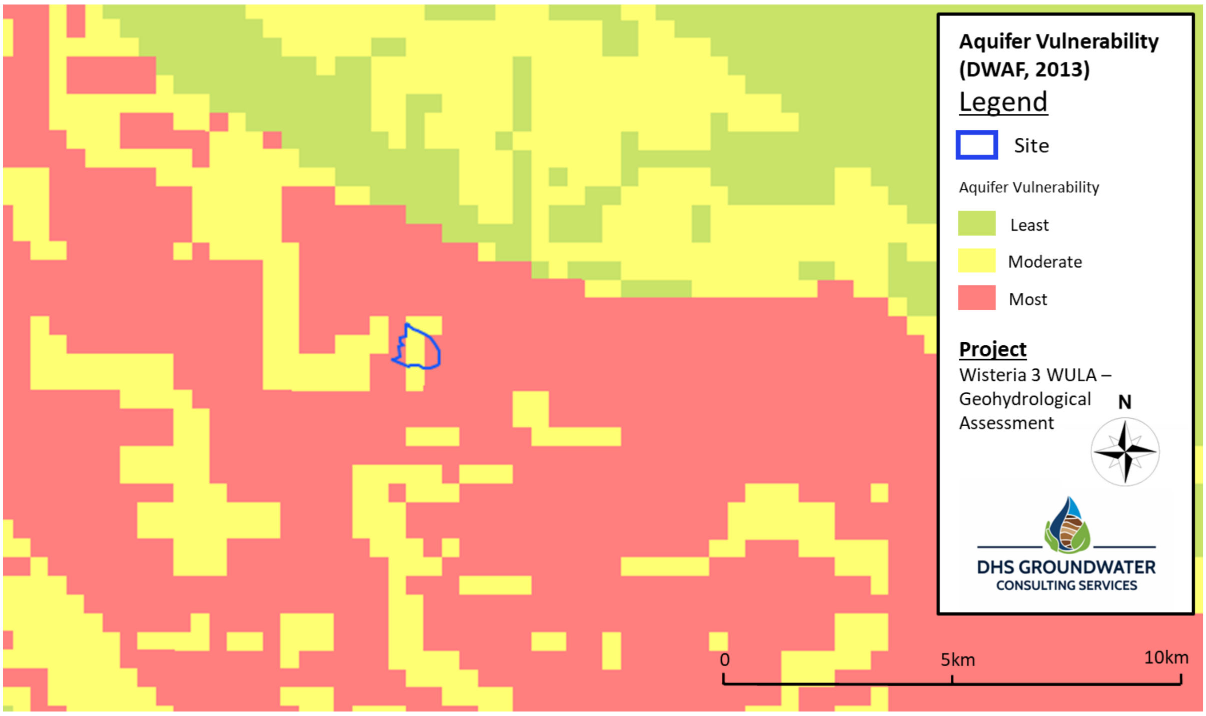


Figure 3. Regional groundwater vulnerability for the study area (DWAF, 2013).

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

6 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). It is important to note that the Klein Rivier was not used as a boundary. The Klein Rivier can be considered as a gaining river being partially fed from the alluvial aquifer within the floodplain through which it flows. There is also a distinct difference in water quality from the alluvial aquifer (very high salinity) and the deeper fractured aquifer (low salinity) from which the production borehole at the site draws water which strongly suggests that these two systems are not hydraulically linked. The borehole on site was specifically constructed to seal off the alluvial aquifer containing inferior water quality.

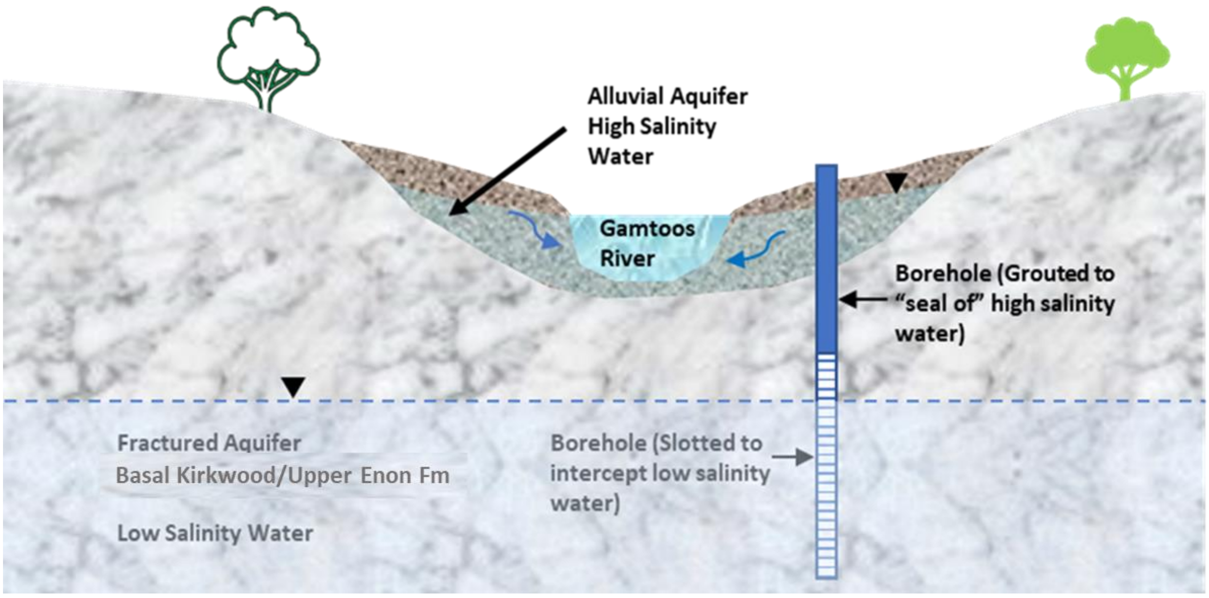


Figure 4. Conceptual model indicating the alluvial aquifer and deeper fractured aquifer

The GRU has been defined as follow:

- The Gamtoos Fault was used as the northern "no-flow" boundary; and
- The eastern, western and southern boundaries were defined by the topographic highs.

The mapped GRU covers a total area of 844 ha and is indicated in Maps 2 & 3, Appendix 1.

7 Site Specific Assessment

7.1 Existing Groundwater Information

7.1.1 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.

A search of the NGA produced zero boreholes within a 1km radius from the site. The search radius was extended to 5km and 7 boreholes were identified. A summary of the data contained in the data base is presented in

Table 3. The regional locations of the boreholes were not plotted due to inaccurate and multiple duplicated coordinates.

Borehole yields extracted from the NGA data is slightly lower than the expected yields as given in the Port Elizabeth Hydrogeological Map (section 5.1). This can probably be attributed to the fact that boreholes were not necessarily drilled into the same geological formations and not scientifically sited. The median static water levels are in accordance with published regional data.

Table 3. Summary of data contained in the NGA

BH Id	Latitude	Longitude	Water Use	BH Depth (m)	SWL (mbgl)	Yield (L/s)
3324DB00117	-33.85600	24.89451		42.06		1.21
3324DD00130	-33.77406	24.91395		25.90		1.58
3324DD00131	-33.77407	24.91395		61.87		0.60
3324DD00132	-33.77406	24.91396		23.46		
3324DD00133	-33.77408	24.91395		45.72		
3324DD00134	-33.77406	24.91397		24.99		
EC/L90/0259	-33.83698	24.88720		166.00	60.20	
			n	7	1	3
			Min	23.46	60.20	0.60
			Max	166	60.20	1.58
			Median	42.06	60.20	1.21

7.1.2 Water Use Authorization & Registration Management System (WARMS)

WARMS data (updated 20 September 2022) was acquired for the study area to establish the volume of lawful groundwater use within the GRU. One registered groundwater user is listed within the delineated GRU.

7.2 Hydrocensus

A hydrocensus was conducted from 05 August 2022 to 09 August 2022 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 6 boreholes were identified on neighbouring properties.

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

From the hydrocensus data it can be concluded that there is an increasing number of groundwater users within the GRU and where groundwater is abstracted, it is mainly used for agricultural purposes (irrigation watering). High EC values often exceeding the SANS drinking water standards limits the water use for agricultural purposes.

The reported yields obtained from the hydrocensus are not in accordance with the Port Elizabeth Hydrogeological Map. As mentioned above, this could be due to boreholes drilled into different geological formations and/or not scientifically sited.

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 4. Details of boreholes located on neighbouring properties

BH nr	Coordinates Decimal Degrees (WGS84)	Depth (m)	Estimated Yield (l/s)	EC (mS/m)	Static water level (mbgl)	Equipment	Water Use	Property Owner (Cell nr.)
WMBH1	S -33.806588 E 024.901207	234	7.22	146	~	Submersible	Irrigation	Warren Meyer (073 268 8992)
WYBH1	S -33.816926 E 024.893563	100	1.39	166	~	Submersible	Domestic	William Young (072 074 6013)
WKBH1	S -33.806878 E 024.897877	150	6.94	153	15.7	Submersible	Irrigation	Waldo Kleyn (072 671 3559)

BH nr	Coordinates Decimal Degrees (WGS84)	Depth (m)	Estimated Yield (l/s)	EC (mS/m)	Static water level (mbgl)	Equipment	Water Use	Property Owner (Cell nr.)
WKBH2	S -33.807319 E 024.907431	180	5	98	11.2	Submersible	Irrigation	Waldo Kleyn (072 671 3559)
PFBH1	S -33.818402 E 024.906927	200	19.44	172	~	Submersible	Irrigation	Pietie Ferreira (082 445 0555)
PFBH2	S -33.819516 E 024.897045	120	4.17	276	42.11	Unequipped	~	Pietie Ferreira (082 445 0555)

WMBH1

WYBH1

WKBH1

WKBH2

PFBH1

PFBH2

Figure 5. Borehole photos on neighbouring properties

7.3 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 south-westerly direction along the Klein Rivier.

7.4 Pumptesting

The production borehole was pumptested from October to November 2021. The pump tests were conducted by Welltek Services and the pumptesting data is attached in Appendix 4.

7.4.1 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 pumptest, 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 borehole: (1) Step-Drawdown Test and (2) Constant Discharge Test.

7.4.1.1 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.

7.4.1.2 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 48 hours.

7.4.1.3 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.

7.4.2 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).

The pumptesting data for the tested borehole and FC-Solutions is presented in Appendix 4. The calculated sustainable yield for the borehole together with the necessary information to equip the borehole is presented in Table 5.

---

[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.

Table 5. Management Recommendations for the tested borehole

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						
BH1	-33.816814°	024.89695°	134	11.76	50	29664	110	711.94
							Total Volume (m^3/day)	**711.94**
							Total Volume (Mm^3/annum)	**0.260**

 # 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 which can be abstracted from the tested borehole (0.260 Mm^3/a) should never exceed the calculated water available for abstraction from the GRU. If the cumulative calculated sustainable yield of the tested borehole exceeds the water available for abstraction from the GRU, borehole yields or duty cycles need to be reduced.

7.5 Groundwater Quality

A groundwater sample was collected for analysis of the major ions and trace elements from the planned production borehole. Two water samples were also collected from boreholes visited during the Hydrocensus (WMBH1 & PFBH2). 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 6). 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.

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

Table 6. Water quality results compared to SANS 241-1:2015 (edition 2) drinking water standards

Sample Nr.	BH1	WMBH1	PFBH2	Standard Limits
pH	6,7	6,6	6,3	5.0 - 9.7
EC	169	159	316	170
TDS	1100	1018	2022	1200
T-Alk		100	73	~
Cl	441,0	332,0	770,0	300
SO_4	64,0	51,4	214,0	250
NO_3-N	0,00	0,00	0,00	11
NO_2-N	0,00	0,00	0,00	0,9
NH_4-N	0,00			1,5
F	0,00	0,11	0,17	1,5
Ca		28,00	58,00	~
Mg		38,00	76,00	~
Na	228,00	219,00	597,00	200
K		14,00	18,00	~
Fe	0,52	0,99	2,50	0,3
Mn	0,15	0,18	0,35	0,1
B	0,13			2,4
Cu	0,00	0,00	0,00	2
Pb	0,00	0,00	0,00	0,01

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

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

Within the site boundaries, BH1 has elevated Sodium, Chloride, Iron and Manganese concentrations exceeding the SANS241 drinking water standards, thus rendering this borehole unfit for human consumption.

Boreholes WMBH1 and PFBH2 were sampled outside the site boundaries as part of the hydrocensus. These two boreholes share similarities with the borehole within the site as they exhibit elevated concentrations of Chloride, Sodium, Iron and Manganese. PFBH2 also has EC and TDS above the permissible drinking water standards. The groundwater within both WMBH1 and PFBH1 is unsuitable for human consumption without prior treatment.

Of the three sampled boreholes, none comply with the SANS241 Drinking Water Standards.

The elevated levels of the constituents are likely contributed to the geological formation present and its chemical composition.

8 Reserve Determination & Water Balance

The sustainable volume of groundwater that can be abstracted from the aquifer(s) underlying the site was determined using data from the GRAII and WARMS datasets[14, 18]. Associated information was collated from governmental and open-source datasets[19, 20]. The reserve is taken into account when calculating the volume of water available for abstraction.

The site falls within quaternary catchment L90B 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.

8.1 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:

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

where:

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.

[18] Department of Water and Sanitation. Section 21(a) of the National Water Act, Taking Water From A Water Resource. DW760 Report. Accessed: 25 April 2022.

[19] Department of Water and Sanitation. Notice 538 of 2016. National Water Act, 1998 (Act No. 36 of 1998). Revision of General Authorisation for the Taking and Storing of Water.

[20] https://wazimap.co.za/ Census Data.

8.2 Water Demand and Abstraction Classification

The calculated recommended groundwater available for abstraction for the site is 0.78 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)

8.3 Assessment on Quaternary Level

The property falls within quaternary catchment L90B and the most salient parameters relevant to this catchment is presented in Table 7.

Table 7. Most salient parameters relevant to catchment L90B.

Area km^2	Protected Area (km^2)[18]	GA $(m^3/ha/a)$[19]	Recharge (Mm^3/a)[14]	Population[20]	Basic Human Need (Mm^3/a)	EWR Baseflow (Mm^3/a)[5]	Reserve (Mm^3/a)[5]	Current use (Mm^3/a)[18]
365.81	0	275	13.691	11 552	0.105	2.857	2.962	0.036

It is assumed that General Authorisation as a possible route can be excluded.

8.3.1 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

= 0.036/13.691

= 0.0026

The quaternary catchment is classified as Category A, which indicates “unstressed” levels of stress in terms of abstraction/recharge (Table 8).

Table 8. Guideline for determining the level of stress[21]

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

8.3.2 Reserve & Water available for allocation

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

Table 9. A summary of the Reserve for quaternary the catchment L90B.

Quantification of Reserve L90B		
Recharge:		
	Recharge **[Mm^3/a]**	13.691
Human Need:		
	Population	11 552
	Basic human need **[l/d/p]**	25
minus	Basic human need total **[Mm^3/a]**	0.105
Baseflow:		
	Baseflow **[Mm^3/a]**	2.857
	Maint. Low flow **[Mm^3/a]**	0
minus	EWR **[Mm^3/a]**	2.857
Flow:		
minus	Net Flow **[Mm^3/a]**	0
Reserve:		
	Reserve as % recharge	21.63
equals	Groundwater allocation **[Mm^3/a]**	<u>10.729</u>
	Current abstraction **[Mm^3/a]**	<u>0.036</u>

From Table 9 it becomes evident that the allocatable portion of the quaternary catchment far exceeds the current abstraction.

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

8.4 Assessment on Groundwater Resource Unit level

If the calculation is based on the GRU delineated for the project using the Groundwater Resources Assessment Project's (2005) range of recharge and baseflow figures, the following emerges:

Table 10. Water Balance within the Groundwater Resource Unit

Area	**Surface Area (ha)**	**Groundwater Recharge to GRU using recharge figure of** 13120300 m^3/a
GRU	955	358.66 **$m^3/ha/a$**
	Recharge to GRU	342524.439 **m^3/a**
		938 **m^3/day**
		10.9 **l/second**
	Registered Use (WARMS)	36188.0 **m^3/a**
RESERVE	Basic Human Need	1168.0 **m^3/a**
	Base Flow (EWR)	2511180 **m^3/a**
		68.6 **$m^3/ha/a$**
		65557.9919 **m^3/a**
Groundwater available for abstraction		239610 **m^3/a**
		0.240 **Mm^3/a**
		656467 **l/day**
		7.6 **l/second**
	Application (WULA)	0.216 **Mm^3/a**
WULA as % of Groundwater available in GRU		90.15 **%**

Based on the water balance results, it is recommended to apply for an allocation of 0.216 Mm^3/annum which places the application in Category B (medium scale abstractions 60-100% recharge to the GRU) see section 8.2. The tested borehole will be able to supply 100% of the applied for volume.

9 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 "Major Aquifer System". The aquifers are highly productive and even used for Municipal supply.

In order to achieve the Groundwater Quality Management Index a point scoring system, as presented in Table 11 and Table 13 below, was used.

Table 11. 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	3
Minor Aquifer System:	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	

The values in Table 11 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.

The level of protection required of a groundwater system depend, amongst other, on the aquifer system classification class and the fractured extent and connectivity of the aquifers. The assumption is that a higher fracture presence results in a higher aquifer connectivity. An aquifer system management index can be derived with the following equation:

Aquifer System Management Index = Aquifer System Management Class x Fracturing

= 3 x 2 = 6

Table 12. Ratings for the Aquifer System Management Index

Aquifer System Management Index	**Level of Protection**	**Study Area**
<1	Limited	
1 - 3	Low Level	
3 - 6	Medium Level	6
6 - 10	High Level	
>10	Strictly Non-Degradation	

The ratings for the Aquifer System Management Classification and Second Variable Classification (Fracturing) yield an Aquifer System Management Index of 6 for the study area, indicating that a “high” level of groundwater protection is required in terms of prevailing groundwater flow regime management.

Table 13. Ratings for the Groundwater Quality Management (GQM) Classification System:

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

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 0). The level of groundwater protection based on the Groundwater Quality Management Classification:

GQM Index = Aquifer System Management x Aquifer Vulnerability

= 3 X 3 = 9

Table 14. GQM index for the study area

GQM Index	Level of Protection	Study Area
<1 1 - 3 3 - 6 6 - 10 >10	Limited Low Level Medium Level High Level Strictly Non-Degradation	9

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 9 for the study area, indicating that a “High” level of groundwater protection is required in terms of groundwater quality management.

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 “Major Aquifer”, (2) the external groundwater users in the area, and (3) maintain baseflow to the Klein Rivier which drains the subject area.

10 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.

10.1.1 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.			

10.1.2 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 water quality results from boreholes sampled during the hydrocensus, it can be safely assumed that the water quality in the adjacent aquifers are of similar quality.			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	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.			

11 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 boreholes need to be included in the network and are summarised in Table 15 below.

Table 15. Boreholes to be included in Monitoring Network

Borehole(s)	Objective
BH1	Impact Monitoring

Table 16 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 a bi-annual basis to ensure the source is utilised in a sustainable manner.

Table 16. 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 and microbial 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.

12 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 0.216 Mm^3/annum which places the application in Category B (medium scale abstractions 60-100% recharge to the GRU). The tested borehole will be able to supply in 100% of the recommended volume applied for.

From a water quality point of view, elevated Chloride, Sodium, Iron and Manganese exceeding SANS241 drinking water limits were reported in the boreholes within as the site as well as in the two boreholes outside the site sampled during the hydrocensus. One of the boreholes outside the site also has EC and TDS levels which exceed SANS241 drinking water limits and as such is not fit for human consumption.

It is the assessor's professional opinion that adequate information was available to appropriately assess the impact of groundwater abstraction from the production borehole 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.*

13 References

1:250 000 Geological Map (3324 Port Elizabeth). Geological Survey, 1986.

1:500 000 General Hydrogeological Map, Port Elizabeth 3324 (1998)

Department of Water and Sanitation. Notice 538 of 2016. National Water Act, 1998 (Act No. 36 of 1998). Revision of General Authorisation for the Taking and Storing of Water.

Department of Water and Sanitation. Section 21(a) of the National Water Act, Taking Water From A Water Resource. DW760 Report. Accessed: 25 April 2022.

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

Department of Water Affairs and Forestry, 1996. South African Water Quality Guidelines (second edition). Volume 1: Domestic Use.

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

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

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

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.

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

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

https://crudata.uea.ac.uk/cru/data/hrg/ - CRU CL 2.0 data-set comprises monthly grids of observed mean climate from 1961-1990, and covering the global land surface at a 10 minute spatial resolution for up to 14 observed and computed agroclimatic parameters.

https://dffeportal.environment.gov.za/ Protected Areas Register (PAR).

https://wazimap.co.za/ Census Data.

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

MEYER, P S (1998). An explanation of the 1:500 000 General Hydrogeological Map Port Elizabeth 3324. Department of Water Affairs and Forestry, Pretoria.

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

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

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

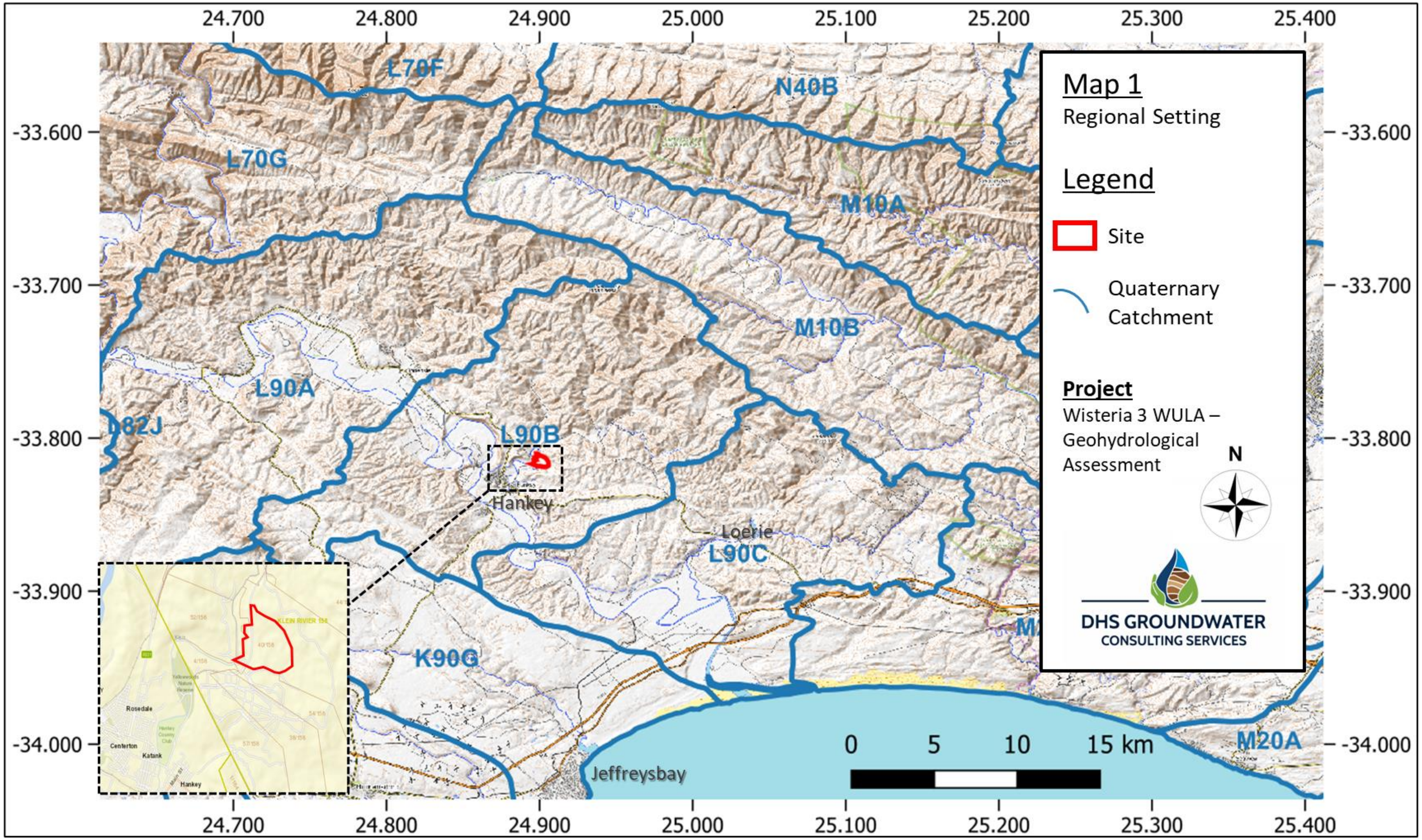
South African National Standard. Development, maintenance and management of groundwater resources. Part 4: Test-pumping of water boreholes (SANS 10299-4:2003, edition 1.1). ISBN 978-0-626-32920-4

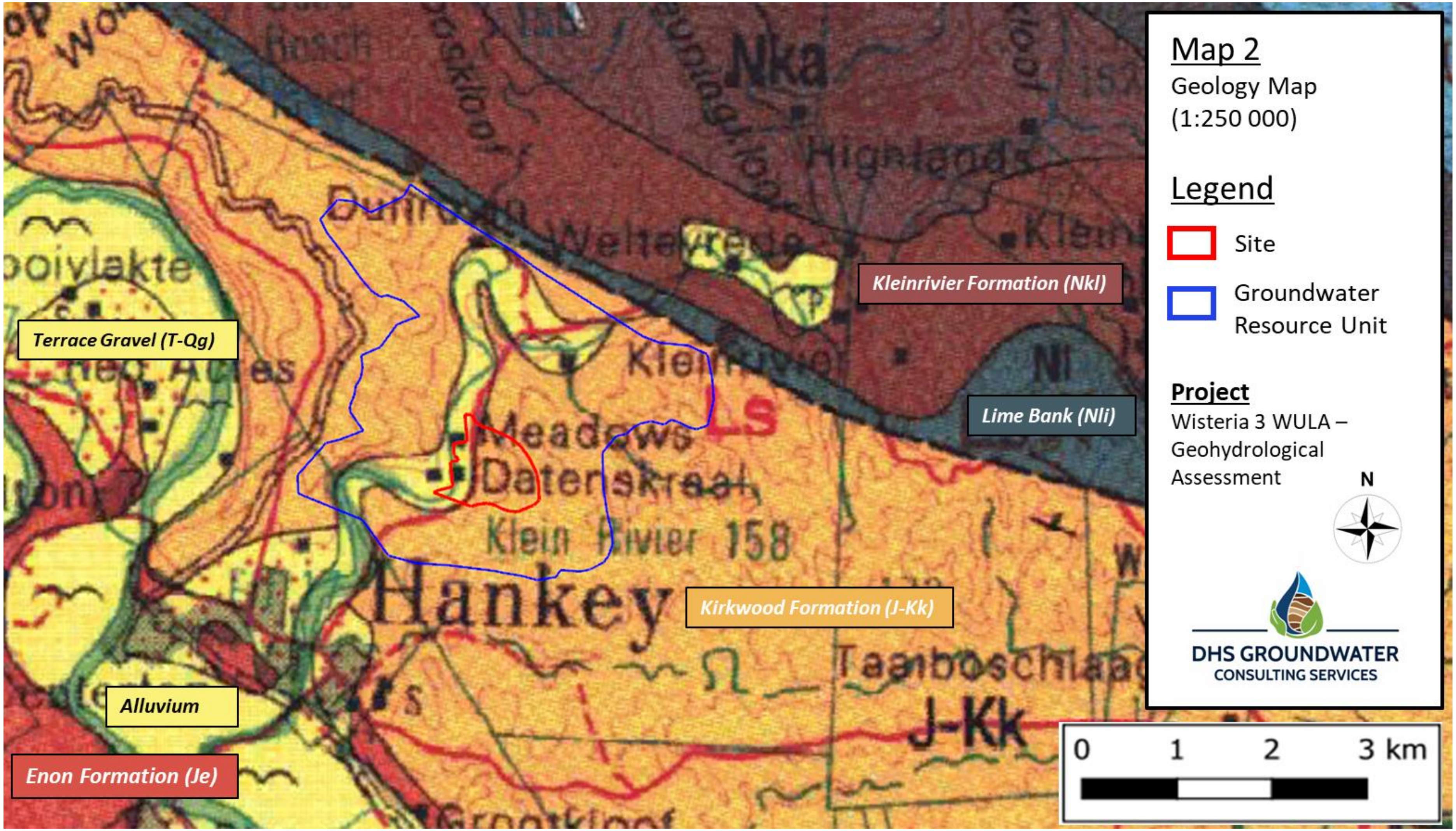
South African National Water Act (Act 36 of 1998)

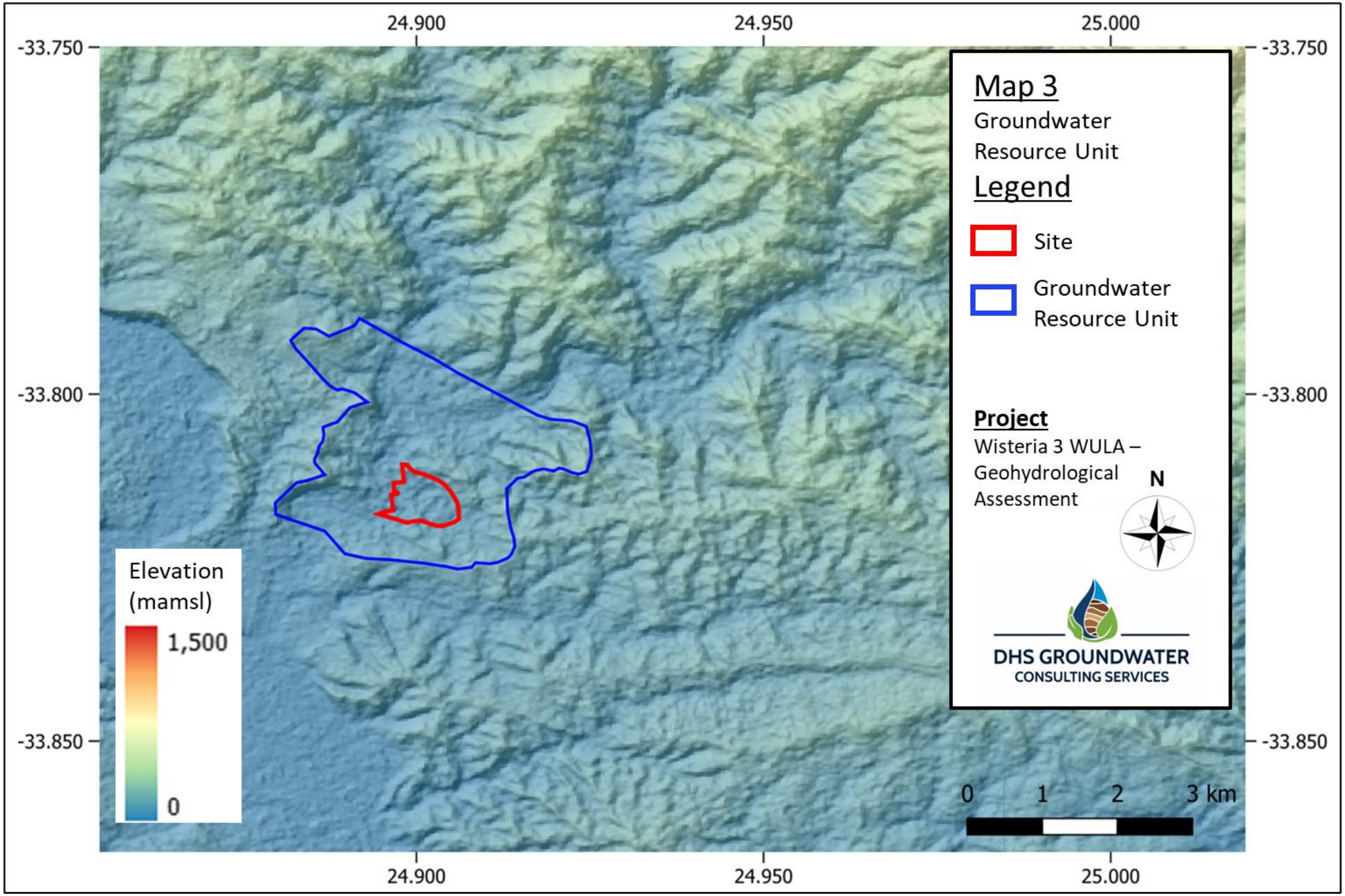
Vegter, J.R. (1995). An explanation of a set of national groundwater maps; WRC Report No. TT 74/95. Water Research Commission, Pretoria

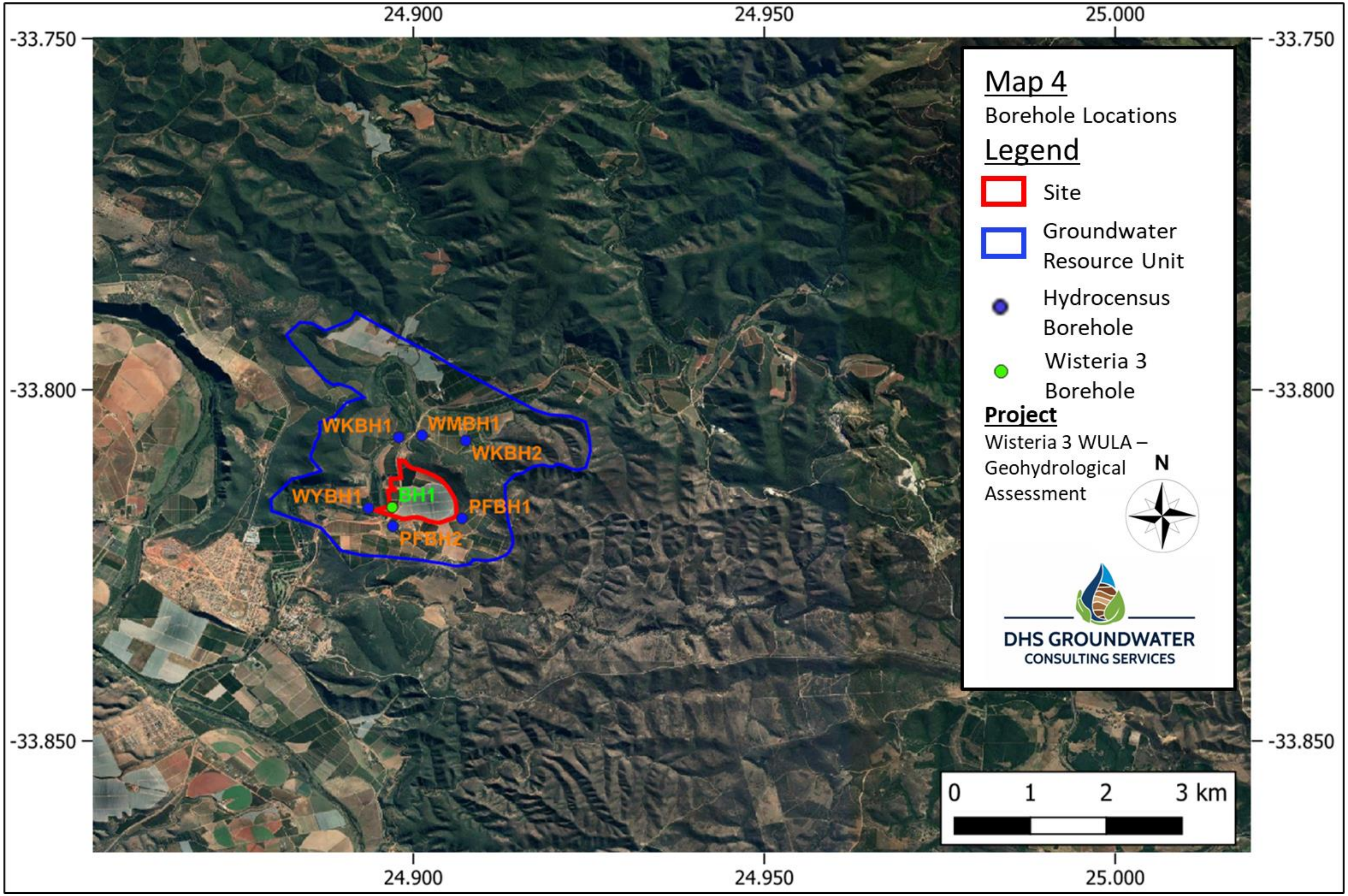
14 Appendices

14.1 Appendix 1: Maps




Map 2
Geology Map
(1:250 000)
Legend
Site
Groundwater Resource Unit
Project
Wisteria 3 WULA – Geohydrological Assessment
N
DHS GROUNDWATER
CONSULTING SERVICES
Kleinrivier Formation (Nkl)
Lime Bank (Nli)
Terrace Gravel (T-Qg)
Kirkwood Formation (J-Kk)
Alluvium
Enon Formation (Je)
Hankey
Klein Rivier 158
J-Kk
0 1 2 3 km


24.900
24.950
25.000
-33.750
-33.800
-33.850
Map 3
Groundwater Resource Unit
Legend
Site
Groundwater Resource Unit
Project
Wisteria 3 WULA – Geohydrological Assessment
N
DHS GROUNDWATER
CONSULTING SERVICES
Elevation (mamsl)
1,500
0
0 1 2 3 km


24.900
24.950
25.000
-33.750
-33.800
-33.850
Map 4
Borehole Locations
Legend
Site
Groundwater Resource Unit
Hydrocensus Borehole
Wisteria 3 Borehole
Project
Wisteria 3 WULA – Geohydrological Assessment
N
DHS GROUNDWATER CONSULTING SERVICES
WKBH1
WMBH1
WKBH2
WYBH1
BH1
PFBH1
PFBH2
0 1 2 3 km

14.2 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)

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

__Please note:__ 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.

- 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.

14.3 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.

14.4 Appendix 4: Pumptesting FC Solutions and Data Sheets

Summary	Wisteria 3 - Kleinrivier BH1						
Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S	AD used
☑	Basic FC	6.71	3.38	23	14.6	2.20E-03	64.9
☐	Advanced FC						
☐	FC inflection point						
☑ TRUE	Cooper-Jacob	8.47	5.48		40.9	3.47E-06	64.9
☐	FC Non-Linear						
☑	Barker	9.54	6.96	K_f = 4	S_s =	1.00E-07	64.9
	Average Q_sust (l/s)	8.24	1.42	b = 0.10	Fractal dimension n =	2.52	

Recommended abstraction rate (L/s)		8.24	29664	l/hr	For 24 hrs per day
Hours per day of pumping (L/s)	12	11.66	41976	l/hr	12 hrs per day
Hours per day of pumping (L/s)	10	12.77	45972	l/hr	10 hrs per day
Hours per day of pumping (L/s)	8	14.27	51372	l/hr	8 hrs per day

Amount of water allowed to be abstracted per month	21358.08	m^3
Borehole could satisfy the basic human need of	28477	persons
Is the water suitable for domestic use (Yes/No)	-	

Recommended pump depth below surface (m)	110		
Total Casing length	134.00		
Blow yield (l/s)	-		
Expected dynamic water level over 24hr pump	50	mbcl	metres below casing level
Critical depth that water level must not exceeded	75	mbcl	
Depth of BH	134.00	mbcl	
Static Water Level	11.76	mbcl	

DHS GROUNDWATER CONSULTING SERVICES
9 Schubert Road
Walmer Heights
Port-Elizabeth
6070
South Africa

T +27 (0) 82 099 2366
E divan@dhsgroundwater.co.za
W https://dhsgroundwater.co.za

Divan Stroebel (Pr.Sci.Nat, MGSSA)
Hydrogeologist - Director
DHS Groundwater Consulting Services
19/11/2021

Management recommendations

The aquifer consists of a good fracture network with radial flow present. Transmissivity is in the order of 14.6 to 40.9 m2/day.
An available drawdown of 75 mbcl is recommended.
As a rule of thumb, 60% of the total available drawdown (depth between main water strike and static water level) can be utilised without jeopardizing aquifer sustainability.
A dynamic water level of 50 mbcl is anticipated over a 24hr pump schedule at a volume of 8.24 l/s.
The water level should not exceed 75 mbcl, which is referred to as the critical water level.
Consistent drawdown below the critical water level will have a negative impact on the aquifer sustainability and yield.
It is therefore HIGHLY recommended to monitor the water level closely during pumping, to prevent drawdown in excess of 75 mbcl.
A conduit should be installed alongside the pump to allow for the measurement of the water level.
A CALIBRATED FLOW METER MUST BE INSTALLED AT THE IMMEDIATE PUMP OUTLET AT THE BOREHOLE TO ENSURE THE RECOMMENDED PUMP VOLUMES ARE NOT EXCEEEDED.

Scenic route 565 t/a Welltek Services
Vat nr: 45902 54720
Email: weltekservices@gmail.com

welltek services
Borehole testing and associated projects

CC Registration nr: 2005/137492/23
18 Highfield Road, EAST LONDON, 5205
Cell: +27 (0)71 031 5086
Fax: +27 (0)86 517 9242

BOREHOLE TEST RECORD

Borehole Number:	BH 5 HANKEY	Province:	EASTERN CAPE
Alternative Number:		District:	HANKEY
Coordinates: Latitude [°S]	33,816680	Town/Village/Farm:	HANKEY
Longitude [°E]	24,896970	Rig Type & number:	ISUZU
Date & Time Test Started:	2021/10/30 00:00	Operator:	THOMAS
Date & Time Test Ended:	2021/11/05 00:00	Supervisor:	HERMAN
Consultant:			
CONSULTANT - DATA PROVIDED / INSTRUCTIONS:		**EXISTING INSTALLATION:**	
Borehole depth [mbgl]:		Diesel/Electric/Wind/Hand	SUBMERSIBLE
Blow Yield [l/s]:		Pump Make & Serial no:	115117A11789
Water Strike Depth(s) [mbgl]:		Intallation Depth (m)	105 M
Installation depth [mbgl]:		Type & Condition - Pump:	CRI SUBMERSIBLE 9,3KW
Estimated Steps [l/s] - Step 1:		- Column:	PVC 80 MM
Step 2:		- Pump House	N/A
Step 3:		**FIELD MEASUREMENTS:**	
Step 4:		Depth Before Test [mbcl]:	134,00
Step 5:		Depth after Test [mbcl]:	134,02
Step 6:		Water Level before Test [mbcl]:	11,76
Step Duration [min]:		Water Level after Test [mbcl]:	11,87
Step Recovery Duration [Hrs]:		Casing Depth [mbcl]:	PVC
Constant Yield [l/s]:		Casing Height [magl]:	0,47
Constant Duration [Hrs]:		Casing Diameter [mm]:	200,00
Recovery Duration [Hrs] / Drawdown %:		**TEST PUMP INSTALLATION DETAILS:**	
Lenghth of Layflat Required [m]:		Pump Used:	GW 9002
Frequency of pH and EC Measurements:		Depth Installed [mbcl]:	112,00
SAMPLE INSTRUCTIONS:		Datum Level above Casing [m]:	0,47
		Length of Layflat [m]:	200,00

GENERAL ACTIONS:

Supplied new steel cover [Yes/No]:	NO	Slug Test [Yes/No]:	N/A
Velded existing steel cover back on [Y/N]:	NO	Re-install existing pump [Yes/No]:	YES LEFT IT WORKING
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:	NO SAMPLE TAKEN

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

STEEL CABLE WAS BROKEN

PULLED PUMP AND JOINED CABLE AGAIN

BOREHOLE NO:	BH 5 HANKEY	WATER LEVEL [mbdl]:	12,23	WATER DEPTH [mbgl]:	11,29	AVAILABLE DRAWDOWN [m]:	100,24

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1 — RPM: — DATE & TIME: 2021/10/30 14:30

TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1	5,86		1	
2	7,42		2	
3	7,94	4,11	3	
5	8,36		5	
7	8,64		7	
10	8,88	4,11	10	
15	8,98		15	
20	9,16		20	
30	9,24	4,1	30	
40	9,38		40	
50	9,48	4,1	50	
60	9,56		60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	
Average Yield (l/s):		4,10	180	
Drawdown (%):		9,54	210	

DISCHARGE RATE 2 — RPM: — DATE & TIME: 2021/10/30 15:30

TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1	9,84		1	
2	10,14	6,42	2	
3	13,02		3	
5	15,14		5	
7	16,12	8,14	7	
10	17,80		10	
15	22,86		15	
20	23,51	8,14	20	
30	24,38		30	
40	24,74		40	
50	25,32	8,15	50	
60	25,54		60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	
Average Yield (l/s):		8,10	180	
Drawdown (%):		25,48	210	

DISCHARGE RATE 3 — RPM: — DATE & TIME: 2021/10/30 16:30

TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1	26,42		1	
2	27,64		2	
3	28,04	10,54	3	
5	29,96		5	
7	30,16		7	
10	30,32	12,04	10	
15	30,60		15	
20	31,18		20	
30	31,44	12,05	30	
40	31,82		40	
50	34,12		50	
60	34,34	12,04	60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	
Average Yield (l/s):		12,00	180	
Drawdown (%):		34,26	210	

DISCHARGE RATE 4 — RPM: — DATE & TIME: 2021/10/30 17:30

TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1	36,96		1	
2	38,47	16,05	2	
3	40,36		3	
5	44,96		5	
7	47,68	16,07	7	
10	52,53		10	
15	55,68		15	
20	63,21		20	
30	66,98	16,05	30	
40	73,48		40	
50	79,82		50	
60	86,96	16,06	60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	
			180	
			210	
			240	
Average Yield (l/s):		16,06	300	
Drawdown (%):		86,75	360	

DISCHARGE RATE 5 — RPM: — DATE & TIME: 2021/10/30 17:30

TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1			1	
2			2	
3			3	
5			5	
7			7	
10			10	
15			15	
20			20	
30			30	
40			40	
50			50	
60			60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	
			180	
			210	
			240	
Average Yield (l/s):		0,00	300	
Drawdown (%):			360	

DISCHARGE RATE 6 — RPM: — DATE & TIME: 2021/10/30 17:30

TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1			1	63,59
2			2	52,12
3			3	46,33
5			5	34,29
7			7	24,18
10			10	16,56
15			15	13,76
20			20	8,54
30			30	7,88
40			40	7,24
50			50	6,56
60			60	5,57
			70	5,02
			80	4,72
			90	4,18
			100	3,44
			110	3,08
			120	2,86
			150	2,64
			180	2,51
			210	2,39
			240	2,17
Average Yield (l/s):		0,00	300	1,98
Drawdown (%):			360	1,84

DATUM LEVEL ABOVE GROUND [m]:	0,94	WAS SAND PUMPED ?	NO
STATIC WATER LEVEL AFTER STEPPED DISCHARGE TEST [mbdl]:	12,23	WAS THE WATER CLEAN?	YES

STEPPED DRAWDOWN SUMMARY

STEP	DURATION [min]	DRAWDOWN [m]	DRAWDOWN [%]	AVERAGE YIELD [l/s]	RECOVERY [min]	RECOVERY [m]	RECOVERY [%]
1	60	9,56	9,54	4,10			
2	60	25,54	25,48	8,10			
3	60	34,34	34,26	12,00			
4	60	86,96	86,75	16,06			
5		0,00		0,00			
6		0,00		0,00			
7							
8							
TOTAL:	240,00	86,96	86,75		0	0,00	0,00

DATE & TIME END: 2021/10/30 18:30

COMMENTS:

ESTABLISHMENT

ESTABLISHMENT DATE: 2021/10/30

SITE MOVE FROM: BOREHOLE	VILLAGE	MOVE TO: BOREHOLE	VILLAGE	DISTANCE BETWEEN BOREHOLES [km]
0	0	BH 5 HANKEY	HANKEY	392,00

BOREHOLE NO:		BH 5 HANKEY			WATER LEVEL [mbdl]:		12,23				WATER LEVEL [mbgl]:		11,29
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:			2021/10/31 11:00		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:			2021/11/06 11:00		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	5,34		1	36,54	1			1			1		
2	6,04	9,13	2	34,19	2			2			2		
3	9,85		3	32,12	3			3			3		
5	13,72		5	30,16	5			5			5		
7	17,36	12,07	7	28,45	7			7			7		
10	21,48		10	26,42	10			10			10		
15	25,62	12,09	15	22,10	15			15			15		
20	26,61		20	18,26	20			20			20		
30	27,47	12,06	30	17,48	30			30			30		
40	27,97		40	16,02	40			40			40		
60	28,52		60	14,34	60			60			60		
90	29,54	12,15	90	12,60	90			90			90		
120	30,07		120	10,73	120			120			120		
150	30,67		150	9,74	150			150			150		
180	30,78	12,15	180	8,46	180			180			180		
210	31,06		210	7,66	210			210			210		
240	31,14	12,17	240	6,80	240			240			240		
300	31,19		300	6,36	300			300			300		
360	31,30		360	6,02	360			360			360		
420	31,64	12,15	420	5,74	420			420			420		
480	31,92		480	5,27	480			480			480		
540	32,24		540	4,84	540			540			540		
600	32,50	12,15	600	4,14	600			600			600		
720	33,12		720	3,92	720			720			720		
840	33,42		840	3,60	840			840			840		
960	33,86	12,16	960	3,32	960			960			960		
1080	34,10		1080	3,14	1080			1080			1080		
1200	34,26		1200	2,86	1200			1200			1200		
1320	34,38	12,15	1320	2,42	1320			1320			1320		
1440	34,48		1440	2,24	1440			1440			1440		
1560	34,57		1560	1,82	1560			1560			1560		
1680	34,68	12,14	1680	1,76	1680			1680			1680		
1800	34,80		1800	1,61	1800			1800			1800		
1920	35,02		1920	1,42	1920			1920			1920		
2040	35,18	12,17	2040	1,34	2040			2040			2040		
2160	35,32		2160	1,25	2160			2160			2160		
2280	35,42		2280	1,12	2280			2280			2280		
2400	35,64	12,15	2400	1,02	2400			2400			2400		
2520	35,79		2520	0,84	2520			2520			2520		
2640	35,98		2640	0,73	2640			2640			2640		
2760	36,12	12,15	2760	0,62	2760			2760			2760		
2880	36,24		2880	0,55	2880			2880			2880		
3000	36,38		3000	0,44	3000			3000			3000		
3120	36,49	12,14	3120	0,32	3120			3120			3120		
3240	36,62		3240	0,28	3240			3240			3240		
3360	36,84		3360	0,26	3360			3360			3360		
3480	37,06	12,17	3480	0,26	3480			3480			3480		
3600	37,20		3600	0,23	3600			3600			3600		
3720	37,37		3720	0,21	3720			3720			3720		
3840	37,54		3840	0,20	3840			3840			3840		
3960	37,68	12,17	3960	0,19	3960			3960			3960		
4080	37,82		4080	0,18	4080			4080			4080		
4200	38,12		4200	0,18	4200			4200			4200		
4320	38,28	12,19	4320	0,17	4320			4320			4320		
DURATION TOTALS [min]			CDT:	4320		RECOVERY:	4320	OBS 1:	0	OBS 2:	0	OBS 3:	0
DRAWDOWN / RECOVERY [m]			CDT:	38,28		RECOVERY:	0,17	OBS 1:	0,00	OBS 2:	0,00	OBS 3:	0,00
DRAWDOWN / RECOVERY [%]			CDT:	38,19		RECOVERY:	99,56	OBS 1:	0,00	OBS 2:	0,00	OBS 3:	0,00
AVERAGE YIELD [l/s]			CDT:	12,16		COMMENTS:							
GENERAL ITEMS AND MAINTENANCE													
TRAVELING FOR VERIFICATION [km]:					SAMPLE TRANSPORTATION [km]:				TRANSPORT EXISTING EQUIPMENT [km]:				

14.5 Appendix 5: Laboratory Reports

Final Report

Pathcare, St George's Hosp
40 Park Drive
Central P.E.
Tel: 041 391 5700

PathCare
Practice No:5200539

Report to:
WISTERIA PAKHUIS (PTY) LTD
ATT: BELINDA SMITH
PO BOX 254
6335 PATENSIE

Referred by: **WISTERIA PAKHUIS (PTY) LTD**

Requisition No: **810386771**
Specimen No: 0815:BS00052R
Collection Date: 2022-08-15 09:13
Received Date: 2022-08-15 12:44
Reported Date: 2022-08-29 16:18

Patient: *(FileNo: BELINDA SMITH) (RefNo: NOT SUPPLIED)*
BHS KLEINRIVIER WATER
Patient ID No: 22:810386771
Age:Sex:DoB: U
Contact No: 0410001515

Guarantor:
WISTERIA PAKHUIS (PTY) LTD
Med Aid: CLIENTS
Member No: NOT AVAILABLE
Contact No: 0793377923

Tests requested: SANS 241 DRINKING WATER

ICD10 code(s): Z76.9

Biochemistry

Test Name	Result	Flag	Reference Range
RISK: Operational			
ALUMINIUM	18		0-300 ug/L
PH VALUE	6.7		5.0-9.7 pH units
TURBIDITY	15		NTU
Guidelines: Operational Aesthetic		0-1 NTU 0-5 NTU	
RISK: Aesthetic			
AMMONIA N	< 0.1		0-1.5 mg/L
CHLORIDE	441	H	0-300 mg/L
CONDUCTIVITY mS/m @ 25 C	169.00		0-170 mS/m
SODIUM	228	H	0-200 mg/L
TOTAL DISSOLVED SOLIDS	1100		0-1200 mg/L
TURBIDITY	15		NTU
Guidelines: Operational Aesthetic		0-1 NTU 0-5 NTU	
ZINC	< 0.20		0-5 mg/L
WATER COLOUR	110	H	0-15 mg/l Pt
RISK: Acute Health 1			
CYANIDE FREE/TOTAL	< 10		0-200 ug/L
NITRATES	< 0.18		0-11 mg/L
NITRITE	0.0		0-0.9 mg/L
RISK: Chronic health			
ANTIMONY	< 7		0-20 ug/L
ARSENIC (As)	< 7		0-10 ug/L
CADMIUM (Cd)	< 1		0-3 ug/L
CHROMIUM (Cr)	< 4		0-50 ug/L
COPPER (Cu)	< 50		0-2000 ug/L
FLUORIDE	< 0.2		0-1.5 mg/L
LEAD (Pb)	< 6		0-10 ug/L
MERCURY (Hg)	< 4		0-6 ug/L
NICKEL	< 5		0-70 ug/L

Generated: 2022-08-29 16:18

Page 1 of 2

Report to: WISTERIA PAKHUIS (PTY) LTD **Requisition No:** 810386771 ***Patient:*** BHS KLEINRIVIER WATER

SELENIUM		< 15	0-40 ug/L
RISK: Multiple			
IRON		520	ug/L
	Guidelines: Aesthetic Chronic health		 0-300 ug/L 0-2000 ug/L
MANGANESE		150	ug/L
	Guidelines: Aesthetic Chronic health		 0-100 ug/L 0-400 ug/L
SULPHATES		64	mg/L
	Guidelines: Aesthetic Acute health		 0-250 mg/L 0-500 mg/L
Reference:			
.		.	
	Sampling done by client. Test results are specific only to the sample tested. Samples from the same or similar source may deliver a different result. Water testing was performed by Pathcare's wholly owned subsidiary, Bemlab Pty Ltd Accreditation number T0654 For a list of accredited analytes, please contact Bemlab at 021 8531490 or email admin@bemlab.co.za Guidelines as per SANS 241-1:2015 Drinking water.		
BARIUM (Ba) (H20)		75	0-700 ug/L
FREE CHLORINE (WATER)		0.05	0-5 mg/L
	Guidelines: Chronic health		 < 5 mg/L
URANIUM (U) (H20)		< 12	0-30 ug/L
TOTAL ORGANIC CARBON (H20)		< 5	0-10 mg/L
BORON (WATER ANALYSIS)		130	0-2400 ug/L

Authorised on 2022-08-29 16:00:00
For consultation, contact a Pathologist - 0413915700
H=High, L=Low, *H=Critically High, *L=Critically Low, #=Delta Checked
In rare cases, analytical interference may cause erroneous results.
Please inform pathologist if results and clinical picture do not concur.
~ File [ ] Phone Patient [ ] Appointment [ ] Prescription [ ] Draw File [ ]

Generated: 2022-08-29 16:18 **End of Report** Page 2 of 2

TALBOT

A Level 1 B-BBEE company

sanas Testing Laboratory T0122

[006771/22], [2022/08/23]

Certificate of Analysis

Project details

Customer Details

Company name:	DHS GROUNDWATER CONSULTING SERVICES
Contact address:	9 SCHUBERT ROAD, PORT ELIZABETH, 6070
Contact person:	DIVAN STROEBEL

Sampling Details

Sampled by:	CUSTOMER
Sampled date:	2022/08/05

Sample Details

Sample type(s):	GROUNDWATER SAMPLES
Date received:	2022/08/15
Delivered by:	CUSTOMER - PORT ELIZABETH LAB
Temperature at sample receipt (°C):	4.5

Report Details

Testing commenced:	2022/08/15
Testing completed:	2022/08/23
Report date:	2022/08/23
Our reference:	006771/22

Analytical Results

Methods	Determinands	Units	021400/22	021401/22
			WMBH1 05.08.2022	PFBH2 09.08.2022
Chemical				
93	Dissolved Calcium*	mg Ca/ℓ	28	58
93	Dissolved Potassium*	mg K/ℓ	14	18
93	Dissolved Magnesium*	mg Mg/ℓ	38	76
93	Sodium*	mg Na/ℓ	**219**	**597**
83A	Copper	µg Cu/ℓ	<1	<1
83A	Iron	µg Fe/ℓ	991	**2499**
83A	Manganese	µg Mn/ℓ	184	345
83A	Lead	µg Pb/ℓ	1.8	<1
10G	Total Alkalinity	mg $CaCO_3$/ℓ	100	73
16G	Chloride	mg Cl/ℓ	**332**	**770**
123	Free Chlorine*	mg Cl_2/ℓ	<0.1	0.18
122	Monochloramine*	mg/ℓ	<3	<3
40A	Colour (True)*	mg Pt-Co/ℓ	<10	<10
2A	Electrical Conductivity at 25°C	mS/m	159	**316**
18G	Fluoride	mg F/ℓ	0.11	0.17
65Gc	Nitrate	mg N/ℓ	<0.25	<0.25
65Gb	Nitrite	mg N/ℓ	<0.05	<0.05
Calc.	Combined Nitrate + Nitrite (sum of Ratios)*	-	<0.12	<0.12
4	Turbidity	NTU	**126**	**208**
1	pH at 25°C	pH units	6.6	6.3
67G	Sulphate	mg SO_4/ℓ	51.4	214
Calc.	Total Hardness*	mg $CaCO_3$/ℓ	225	456
Microbiological				
32	*E.coli**	MPN/100mℓ	<1^	**10^**
32	Total Coliforms*	MPN/100mℓ	10^	**3873^**
31	Standard Plate Count*	colonies/mℓ	154^	**>1000^**

Refer to the "Notes" section at the end of this report for further explanations.

Where the laboratory reporting limit for a test is higher than the required specification limit, the raw data is reviewed and the detection limit highlighted in bold font if outside of specification.

Specific Observations

Results that appear in bold do not meet the specification limits in Appendix 1 of this report.

Quality Assurance

Technical signatories

Inorganic Chemistry: Thembisa Mbanjwa

Microbiology: Olivia Magaya

Notes to this report

Limitations

This report shall not be reproduced except in full without prior written approval of the laboratory.
Results in this report relate only to the samples as taken, and the condition received by the laboratory.
Any opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
The decision rule applicable to this laboratory is available on request.
Sample preparation may require filtration, dilution, digestion or similar. Final results are reported accordingly.
Where the laboratory has undertaken the sampling, the location of sampling and sampling plan are available on request. Talbot Laboratories is guided by the National Standards SANS 5667-3:2006 Part 3 Guidance on the Preservation and Handling of Water Samples; SANS 5667-1:2008 Part 1 Guidance on the Design of Sampling Programmes and Sampling Techniques and SANS 5667-2:1991 Part 2: Guidance on Sampling Techniques. Customers to contact Talbot Laboratories for further information.

Uncertainty of measurement

Talbot Laboratories' Uncertainty of Measurement (UoM) values are:

- Identified for relevant tests.
- Calculated as a percentage of the respective results.
- Applicable to total, dissolved and acid soluble metals for ICP element analyses.
- Available upon request.

Analysis explanatory notes

Tests may be marked as follows:

^	Tests conducted at our Port Elizabeth satellite laboratory.
*	Tests not included in our Schedule of Accreditation and therefore that are not SANAS accredited.
#	Tests that have been sub-contracted to a peer laboratory.
NR	Not required -shown, for example, where the schedule of analysis varied between samples.
σ	Field sampling point on-site results.
a	Testing has deviated from Method.