GROUNDWATER REPORT FOR THE ESTABLISHMENT OF A FUEL SERVICE STATION AND RELATED STRUCTURES AND INFRASTRUCTURE ON A PORTION OF PROPERTY 312, HARTSWATER DISTRICT, NORTHERN CAPE

January 2023

Prepared for:

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Holding 54

Hartswater

Northern Cape

Report prepared by:

Report	Groundwater observation and desktop report.
Client/Project	The proposed establishment of a fuel service station and Truckstop with associated structures and infrastructure on a portion of holding 312 in the Hartswater district of the Northern Cape.
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1 BACKGROUND AND PROJECT DESCRIPTION

Tulo Ya Batho (Pty) Ltd is proposing the establishment of a fuel service station on a portion of holding 312 in the Hartswater district of the Northern Cape.

The proposed site is located approximately 7.5km to the west (i.e., towards Pampierstad) of the N18 between Jan Kempdorp to Hartswater and is situation approximately 4km to the east of Pampierstad. Reference is made to **Error! Reference source not found.**.

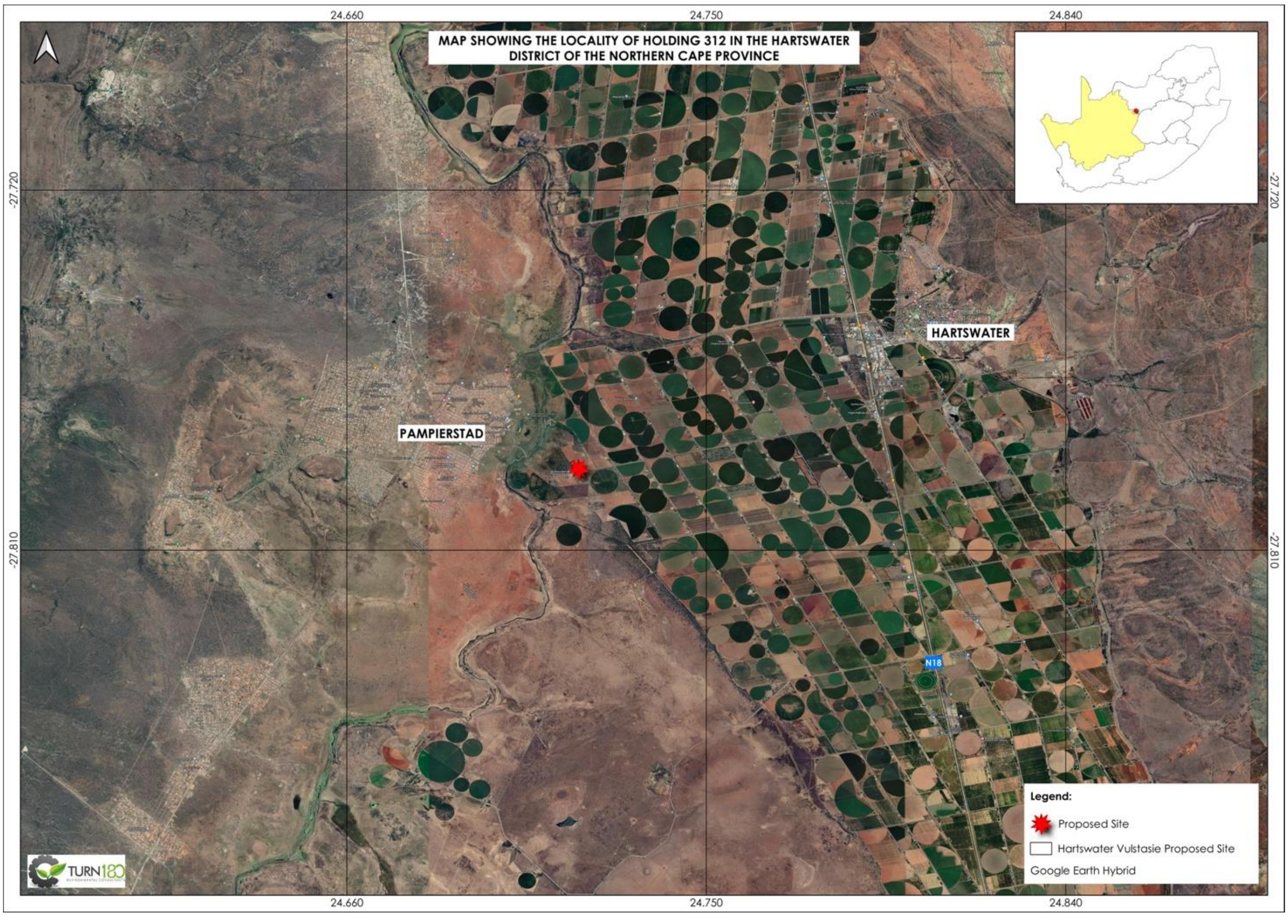

Figure 1: Locality map of the proposed fuel station

The proposed project entails the development of the following:

- Fuel service station with diesel and petrol pumps, including the underground bulk storage facilities (i.e., tanks),
- Convenience store with station ablutions,
- Truck stop and driver ablutions,
- Parking areas,
- Fast food outlet.

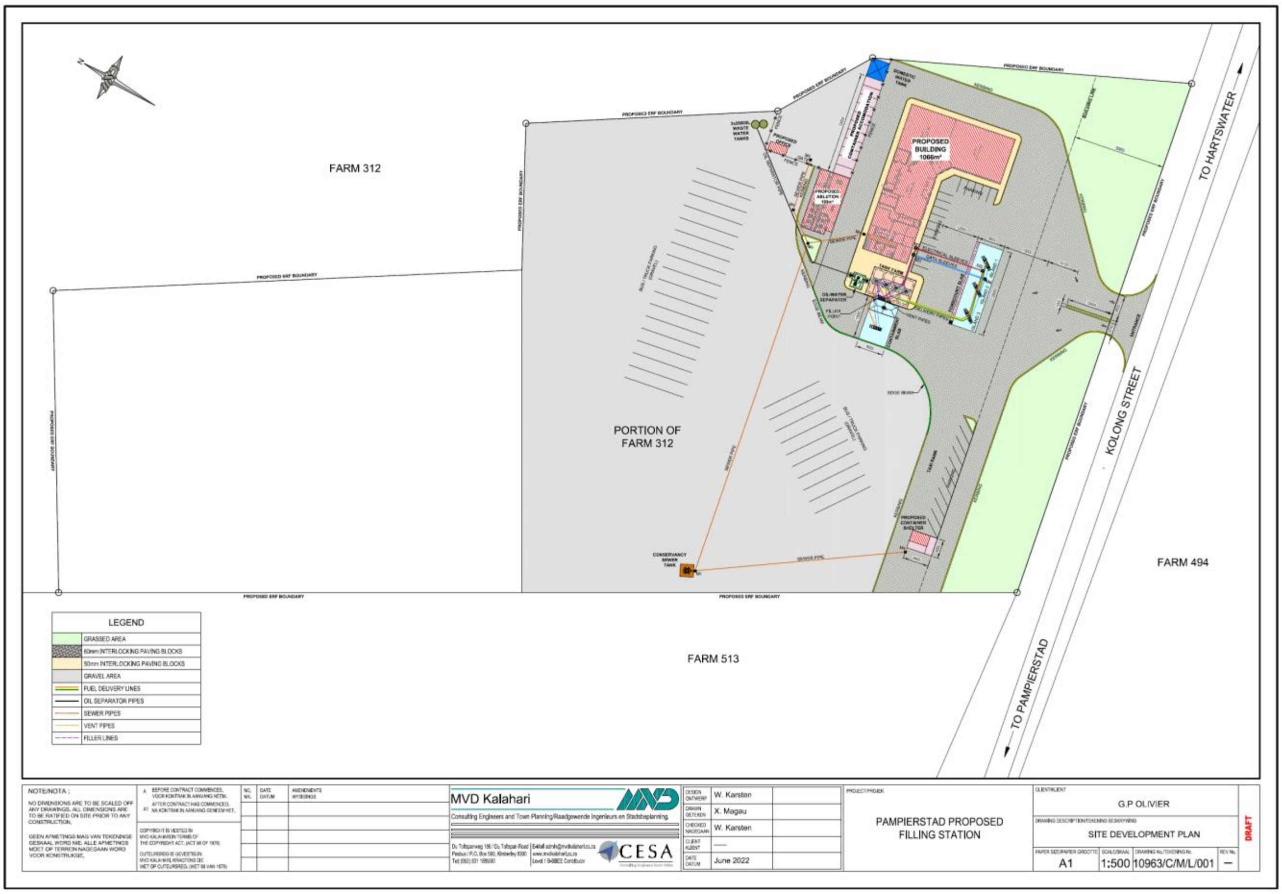

Figure 2: Proposed layout of the fuel service station on a portion of farm 312 (MVD Kalahari, 2022).

According to Kalahari MVD (2022) conservancy tanks with a capacity of 25 m³ will be installed and serviced by the local municipality or contractors.

Water will be obtained either from the water scheme or from existing borehole(s) on the property. A Total Annual Average Daily Demand ("TAADD") of 12.448 m³water/day was calculated by MVD Kalahari (2022). The development will thus require a total annual volume of 4 543.52 m³ of water.

The proposed site is flat with gentle slopes which will drain towards the north east into the drainage channel located approximately 500m to the north east of the site. This drainage channel ultimately drains into the Harts River. Reference is made to Figure 3 below. Groundwater flow generally follows the surface topography and drains to the lowest points. This also implies that groundwater flow will be from high gradient or positive hydraulic head to low gradient. This is important to note as groundwater will tend to recharge depressions where water was abstracted.

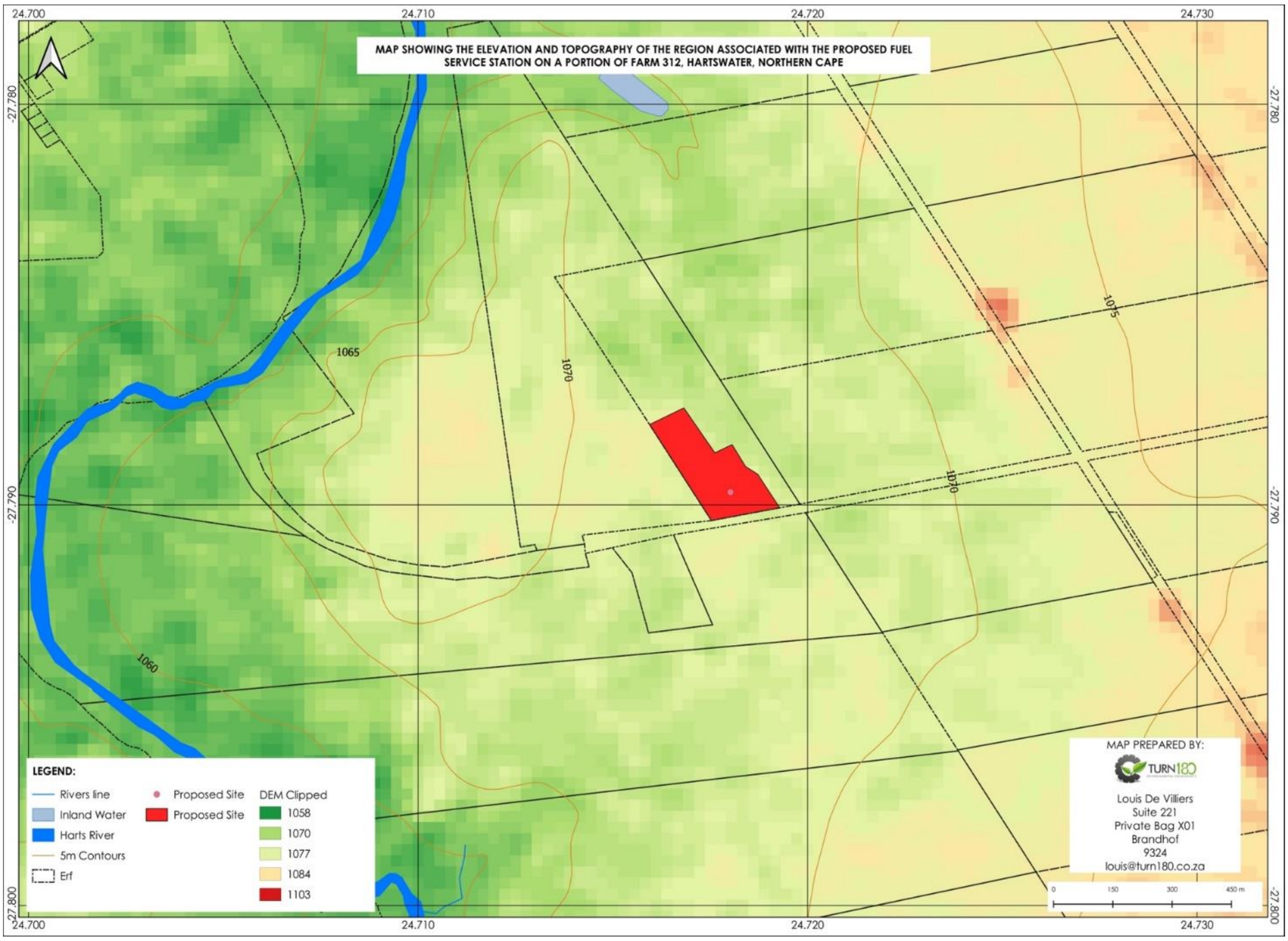

Figure 3: Map showing the topography and elevations of the region (Turn 180, 2023)

2 REGIONAL GEOLOGY AND GEOHYDROLOGY

2.1 GEOLOGY

According to the 1:250 000 Geological Survey Data Map (2724 Christiana) (Council for Geoscience, 1994), the study area under investigation is predominantly overlain by aeolian sand and forms part of the Kalahari Group as indicated under legend Qw.

GeoCalibre Geotechnical Consultancy (2022) classified the soil conditions over 8 test pits on the site as 1) topsoil with an average depth and thickness of 0.83m underlain by 2) Calcified Aeolian Sand with an average thickness of 1.51m ranging from depth 0.83m to 2.34m which is underlain by 3) Concretionary Calcrete from 2.34m to 3.03m (average depth of test pits).

The area is described in the Dc5 land type.

Reference is made to Figure 4 below.

2.2 GEOHYDROLOGY

According to the regional 1:500 000 hydrogeological map of Kimberley, 2722 issued by the Department of Water Affairs and Forestry (**"DWAF"**) (2003) which is utilised to estimate the principal groundwater occurance of the area, the study area is located within zone b2. Aquifer types associated with this zone is known as a fractured aquifer type with a borehole yield of 0.1 – 0.5 ℓ/s.

Reference is made to Figure 5 below.

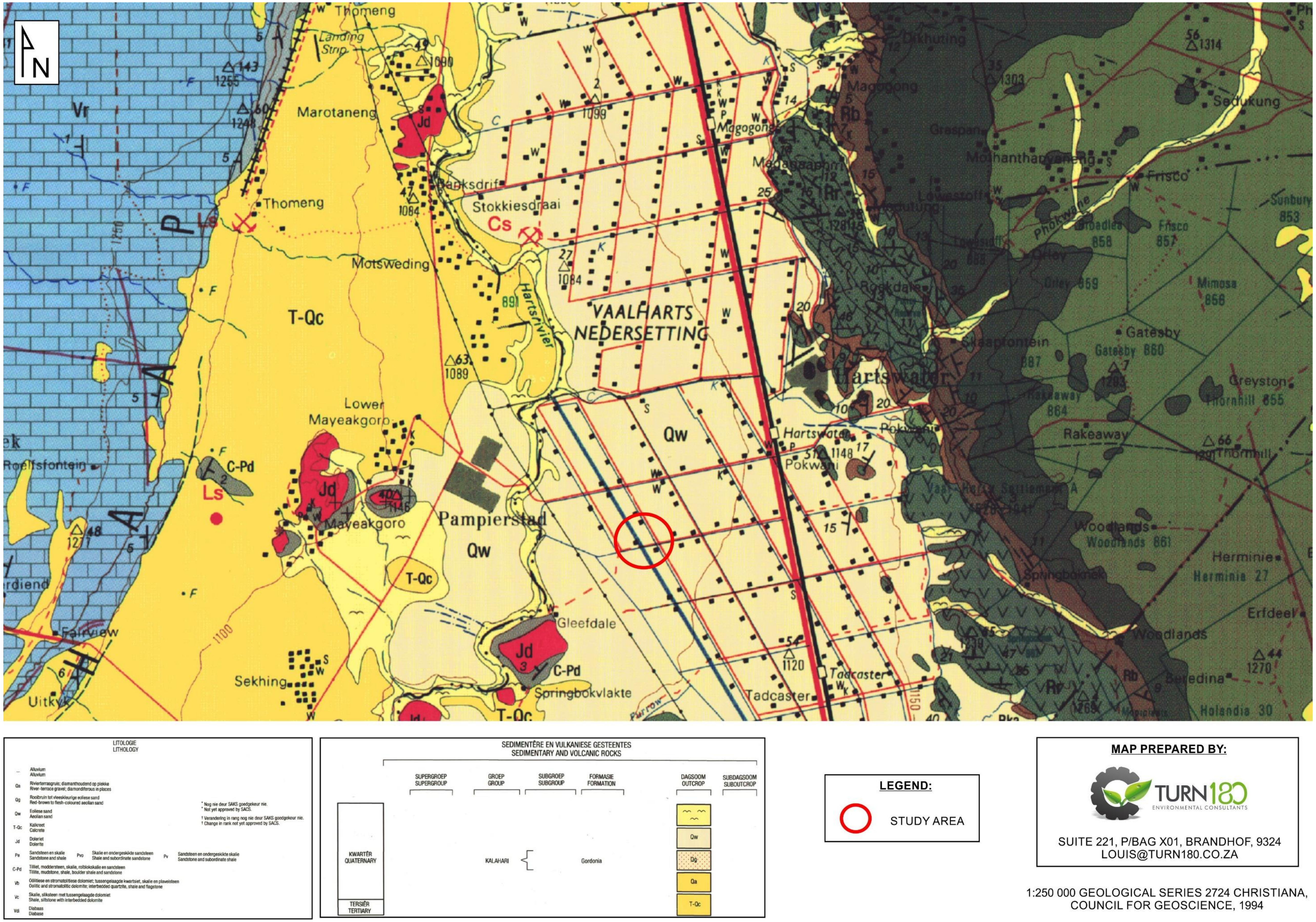

Figure 4: Regional geology of the study area according to Map Christiana 2724 (Council for Geoscience, 1994)

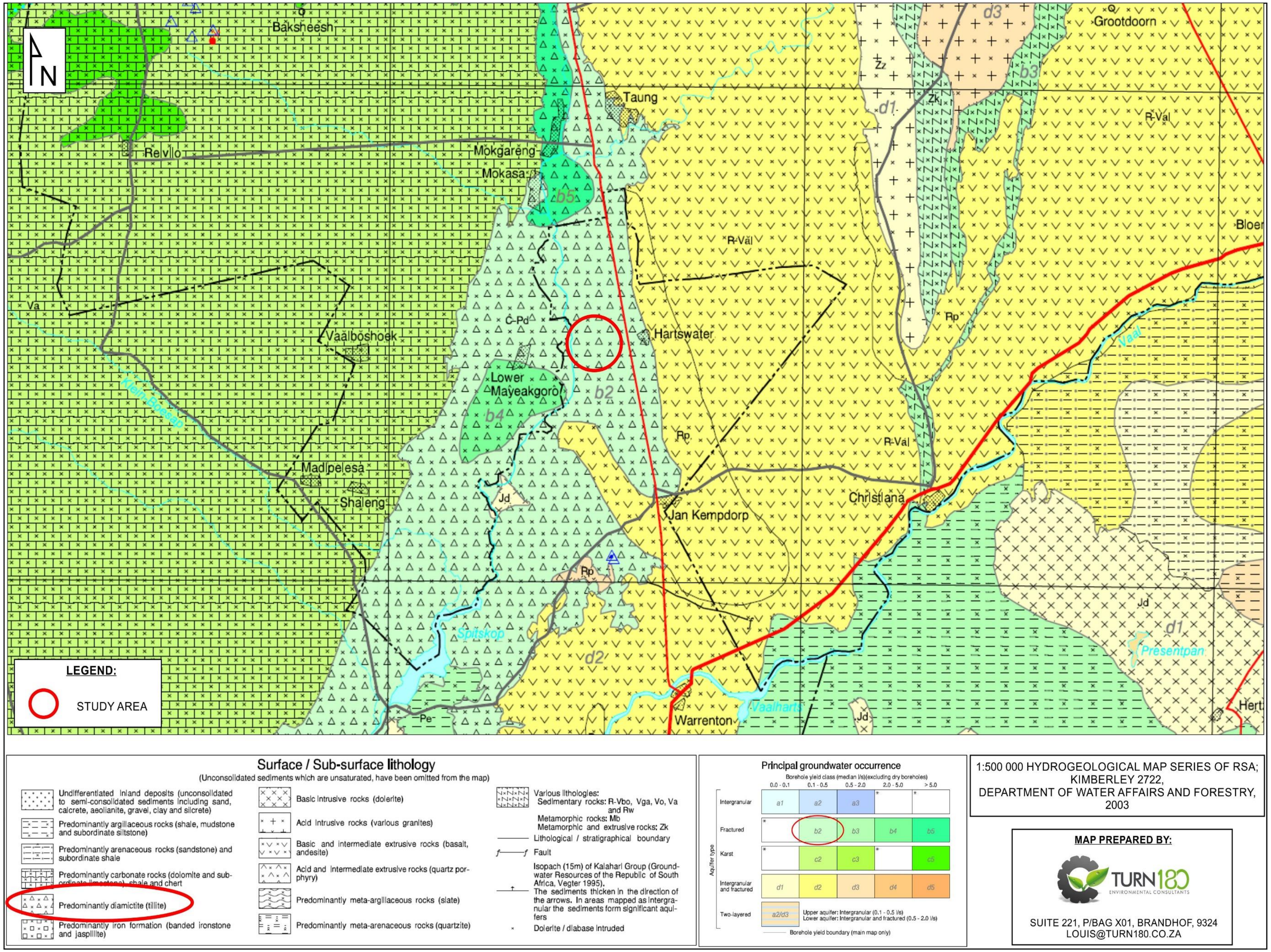

Figure 5: Regional hydrogeology according to Map Kimberley 2722 (DWAF, 2003)

2.3 AQUIFER CLASSIFICATION AND AQUIFER VULNERABILITY

2.3.1 Aquifer Classification and Water Quality

According to the aquifer classification map form the Department of Water Affairs (1999), the aquifer of the area under investigation is classified as a minor aquifer. This is corresponding to the principal groundwater map (Figure 5), indicating possible groundwater occurrence of 0.1 – 0.5L/ for the area under investigation. This aquifer is an aquifer with a moderate yield and variable water quality.

This is supported by the water quality results of groundwater collected on, and adjacent to the site which had an EC (i.e., Electrical Conductivity) of **200 mS/m** (BH1) and **172 mS/m** (BH2). The groundwater quality of these boreholes with respect to EC alone is of moderate quality as it is between 150 – 370 mS/m.

It should be considered that water with an EC level exceeding 170 mS/m is not suitable for human consumption in terms of the SANS 241:2015 standards for drinking water. However, according to the *South African Water Quality Guidelines, Volume 1: Domestic Use* (DWAF, 1996), water with an EC of 150 – 300 mS/m and TDS (i.e., Total Dissolved Solids) of 1 000 – 2 000 mg/ℓ do not appear to produce adverse health effects in the short term. Water with EC and TDS in this range may however have a salty taste and effects on plumbing and appliances such as corrosion and scaling can be expected.

The Turbidity of the water in BH1 wat 88.6 NTU. The limit for Turbidity in drinking water is < 1NTU. "*Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water. The turbidity of water is also related to clarity, a measure of the transparency of water and settleable material, which refers to suspended matter which settles after a defined time period as opposed to that which remains in suspension.*

Micro-organisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. The probability of the presence of carcinogenic asbestos fibres is also reduced under conditions of low turbidity. Turbidity also affects the aesthetic quality of water" (DWAF, 1996). According to the DWAF (1996) water with a Turbidity exceeding 10NTU will have severe aesthetic effects and carries associated risk of disease due to infectious disease agents and chemicals adsorbed onto particulate matter.

The Mg (i.e., Magnesium) in both BH1 and BH2 exceeded the limit of 70 mg/ℓ. The Mg level of BH1 and BH2 was 109 and 127 mg/ℓ respectively. Mg levels between 100 – 200 mg/ℓ will be aesthetically unacceptable because of a bitter taste and will result in increased scaling problems while it will cause diarrhoea in most new water users if sulphate is present (DWAF, 1996). The Sulphate of BH1 and BH2 were 275 and 289 mg/ℓ respectively which has a tendency to develop diarrhoea in sensitive and some non-adaptive individuals.

Although the Hg (i.e., Mercury) levels of both boreholes were 0.01 mg/ℓ it may be because of the lab limits being set at 0.01 mg/ℓ. According to the DWAF (1996) the Target Water Quality of Hg is between 0 – 1 mg/ℓ. At this range there will be no health effects expected.

The DOC (i.e., Dissolved Organic Carbon) in BH1 was 12.66 mg/ℓ which has a risk of health effects depending on the DOC composition.

A sample of water from the scheme canal was also taken and analysed against the drinking water standards. This water complies to drinking water with the exception of Turbidity and Al (i.e., Aluminium). The Al level was 0.9 mg/ℓ with a Target Water Quality of 0.15 mg/ℓ.

In conclusion, it is not recommended that either the groundwater or the canal water be supplied to individuals as drinking water. However, this being said it should be considered that Target Water Quality limits are set against long exposures and intake of the water and these recommendations are made according to Tier 1 guidelines. If water are used for human consumption it is highly recommended that the water be filtered and treated to remove any microbial/ bacteriological pathogens in the water, to reduce the amount of solids in the water and also to lower some of the chemical elements and/or salts which may have negative impacts (either aesthetically or on human health).

Figure 6: Surface and groundwater sample location map (Turn 180, 2022)

Table 1: Table showing the results of the water quality analysis

YANKA LABORATORIES

CHEMISTRY TEST RESULTS

						Domestic Water. Class II is for information only SANS 241:2015 / 2011 / 2006		
LABORATORY NUMBER			SpTurn 1	SpTurn 2	SpTurn 3	SANS 241:2015 STANDARD LIMIT [Operational] [Aesthetic] [2011/other]	Class II (Max Allowance for Limited Duration) *2006	Class II Water Consumption Period, a max *2006
SAMPLE DESCRIPTION			BH 1	BH 2	Kanaal			
SAMPLE NUMBER			E58069-001	E58069-002	E58069-003			
CO-ORDINATES								
SAMPLED		Test Method **	2022/10/29 00:00	2022/10/29 00:00	2022/10/29 00:00			
Remarks			Clear	Brown	Clear			
Depth	m	Electronic probe	2,13	3,54				
Total Alkalinity (pH>4.5)	mg $CaCO_3$/L	YE010Alk	414	360,92	104,19			
Bicarbonate Alkalinity	mg $CaCO_3$/L	YE010Alk	414	341,08	104,19			
Carbonate Alkalinity	mg $CaCO_3$/L	YE010Alk	0	19,84	0			
M Alkalinity (8.3>pH>4.5)	mg $CaCO_3$/L	YE010Alk	414	351	104,19			
P Alkalinity (pH>8.3)	mg $CaCO_3$/L	YE010Alk	0	9,92	0			
Conductivity (Laboratory)	mS/m	YE020CON	200	172	41,3	< 170	150 - 370	7 years
pH (Laboratory)		YE030pH	8,26	8,50	8,02	5.0 - 9.7	4.0 - 10.0	No limit
Total Hardness	mg $CaCO_3$/L	YE061H	611,4912	619,19844	122,7623			
Calcium Hardness	mg $CaCO_3$/L	YE061H	161,8056	97,28312	67,1693			
Magnesium Hardness	mg $CaCO_3$/L	YE061H	449,6856	521,91532	55,593			
Total Dissolved Solids (TDS)	mg/L	Calculation	1131	1020	214	< 1200	1000-2400	7 years
Suspended Solids (TSS)	mg/L	YE081TSS	156	<0.4	26,4			
Temperature	°C	Thermometer	21	21	21			
Turbidity	NTU	YE082TB	88,6	0,57	43,7	< 1	1 - 5	No limit
Oxygen Dissolved (DO)	mg O_2/L	YE051OD	6,68	6,51	6,34			
Ammonia	mg N/L	alculated on pH or	<0.45	<0.45	<0.45			
Ammonium	mg N/L	alculated on pH or	<0.45	<0.45	<0.45			
Ammonia and Ammonium	mg N/L	YE070AK	<0.45	<0.45	<0.45	< 1.5		
Calcium	mg Ca/L	YE060ICP	64,8	38,96	26,9	< 150	150 - 300	7 years
Chloride	mg Cl/L	YE070AK	250	166	32,3	< 300	200 - 600	7 years
Magnesium	mg Mg/L	YE060ICP	109	127	13,5	< 70	70 - 100	7 years
Nitrate and Nitrite (TON)	mg N/L	YE070AK	0,92	12,9	0,59	< 12	10 - 20	7 years
Nitrite	mg N/L	YE070AK	0,73	<0.01	<0.01	< 0.9		
Ortho Phosphate	mg P/L	YE070AK	<0.03	<0.03	<0.03	< 5		
Potassium	mg K/L	YE060ICP	5,85	6,98	5,81	< 50	50 - 100	7 years
Sodium	mg Na/L	YE060ICP	172	118	23,4	< 200	200 - 400	7 years
Silicon	mg Si/L	YE060ICP	5,51	17	2,48			
Sulphate	mg SO_4/L	YE070AK	275	289	45,1	< 500	400 - 600	7 years
Aluminium	mg Al/L	YE060ICP	<0.01	<0.01	0,90	< 0.3	0.3 - 0.5	1 year
Antimony	mg Sb/L	YE060ICP	<0.01	<0.01	<0.01	<0.02		
Arsenic	mg As/L	YE060ICP	<0.009	<0.009	<0.009	<0.01		
Barium	mg Ba/L	YE060ICP	0,01	0,01	0,03			

Beryllium	**mg Be/L**	**YE060ICP**	<0.01	<0.01	<0.01			
Boron	mg B/L	YE060ICP	0,30	0,23	0,02	**< 0.3**		
Cadmium	mg Cd/L	YE060ICP	<0.002	<0.002	<0.002	**<0.003**		
Chromium	mg Cr/L	YE060ICP	<0.01	<0.01	<0.01	**<0.05**		
Cobalt	**mg Co/L**	**YE060ICP**	<0.01	<0.01	<0.01	**< 0.5**		
Copper	mg Cu/L	YE060ICP	0,01	0,01	0,01	**< 2**		
Fluoride	mg F/L	YE070AK	<0.09	<0.09	<0.09	**< 1.5**	**1.0 - 1.5**	**1 year**
Iron	mg Fe/L	YE060ICP	1,11	<0.01	0,76	**< 2**	**0.2 - 2.0**	**7 years**
Lead	mg Pb/L	YE060ICP	0,01	0,01	<0.01	**< 0.01**		
Lithium	**mg Li/L**	**YE060ICP**	0,07	0,02	<0.01			
Manganese	mg Mn/L	YE060ICP	0,07	<0.01	<0.01	**< 0.4**	**0.1 - 1.0**	**7 years**
Mercury	mg Hg/L	060ICP	0,01	0,01	0,01	**<0.006**		
Molybdenum	**mg Mo/L**	**YE060ICP**	<0.01	<0.01	<0.01	**< 0.07**		
Nickel	mg Ni/L	YE060ICP	<0.01	<0.01	<0.01	**< 0.07**		
Selenium	mg Se/L	YE060ICP	<0.01	<0.01	<0.01	**< 0.04**		
Strontium	**mg Sr/L**	**YE060ICP**	1,31	1,39	0,13			
Tin	**mg Sn/L**	**YE060ICP**	0,1	0,09	0,05			
Vanadium	**mg V/L**	**YE060ICP**	<0.01	<0.01	<0.01	**< 0.2**		
Zinc	mg Zn/L	YE060ICP	<0.01	<0.01	<0.01	**< 5**		
Phenol	mg Phenol/L	YE070AK	<0.01	<0.01	<0.01	**< 0.01**		
Total Organic Carbon (TOC)	mg C/L	YE090TOC	32,1	2,96	8,74	**< 10**		
Dissolved Organic Carbon (DOC)	**mg C/L**	**YE090TOC**	12,66	2,88	7,74			
Cyanide (Free)	mg CN/L	070AK	<0.01	<0.01	<0.01	**< 0.2**		
Total Phosphorous	**mg P/L**		0,18	0,01	0,13			
Uranium	mg U/L	YE060ICP	<0.01	0,02	<0.01	**<0.015**		
Bromoform	**µg/L**	**Outsourced**	**<5**	**<5**	**<5**			
Chloroform	**µg/L**	**Outsourced**	**<5**	**<5**	**<5**			
Bromodichloromethane	**µg/L**	**Outsourced**	**<10**	**<10**	**<10**			
Dibromochloromethane	**µg/L**	**Outsourced**	**<2**	**<2**	**<2**			
Trichloroethene (TCE)	**µg/L**	**Outsourced**	**<5**	**<5**	**<5**			
Total THMs **	**µg/L**	**Outsourced**	**<10**	**<10**	**<10**			
Langelier Index (indicative, not SANS)		Calculation	1,10	1,07	-0,04	**-0.5 - 0.5**	**negative: water may corrode surfaces; positive: water may form scale on surfaces due to**	
pHs (indicative, not SANS)		Calculation	7,16	7,43	8,06		**Saturation pH (used in calculations)**	
Sodium Absorption Ratio (indicative)		Calculation	3,01	2,04	0,92	**< 1.5**	**Relevant in irrigation and water/plant/soil interaction**	
TDS to EC Ratio (indicative, not SANS)		Calculation	5,66	5,93	5,18		**Analytical indicator**	
Corrosion Ratio (indicative, not SANS)		Calculation	2,05	1,71	1,10	**0 - 0.3**	**A.k.a. Larson-Skold Index; >0.3: water may (>1.2 would) corrode surfaces due to (sulphate and**	
Ryznar Index (indicative, not SANS)		Calculation	6,06	6,37	8,09	**6 - 7**	**< 6: water may form scale on surfaces; > 7: water may corrode surfaces**	

2.3.2 Aquifer vulnerability and Susceptibility

The objective of defining and mapping aquifer vulnerability is to help planners to protect groundwater as an essential economic resource and to act as a foundation for the designation of protection zones. The concept of aquifer vulnerability derives from the assumption that the physical environment may provide some degree of protection of groundwater against human impacts, especially with regards to pollutants entering the sub surface. Aquifer vulnerability thus combines the hydraulic inaccessibility of the saturated zone to the penetration of pollutants, with the attenuation capacity of the strata overlying the saturated zone (Foster 1998).

The vulnerability of the underground water source is related to the distance that the contaminant must flow to reach the water table, and the ease with which it can flow through the soil and rock layers above the water table. The water level depth map (Figure 8) indicate a water level depth of BH2 on the proposed site at 3.64 mbgl.

According to the aquifer vulnerability map from the Department of Water Affairs (Figure 7), the aquifer of the area under investigated is classified as the least vulnerable. Thus, the aquifer is vulnerable only to conservative pollutants in the long term when continuously leached or discharged.

According to the DWA Map and matrix of Aquifer Susceptibility the region at the study area has a low susceptibility for contamination. This is measured against the vulnerability and classification/ importance of the aquifer.

Figure 7: Aquifer vulnerability. Map – Water Affairs.

2.4 WATER LEVELS AND RECHARGE

The groundwater depth in the study area was measured at 3.54mbgl (static water level). According to the DWA map as Figure 8 below the groundwater level in the region is less than 15mbgl. During the site investigation, measured water levels in BH1 and 2 indicated an average groundwater level depth of 2.84 mbgl. However, only BH2 is located on the site and the water level of this boreholes was measured at 3.54 mbgl.

The mean annual recharge of the area is between 15 - 25 mm (refer to Figure 9). The Vegter recharge maps estimates the recharge as 20 mm/a (refer to Figure 10). The DWA and Vegter data estimates the recharge percentage as 6.25% for the area under investigation if the annual rainfall of 320mm is used.

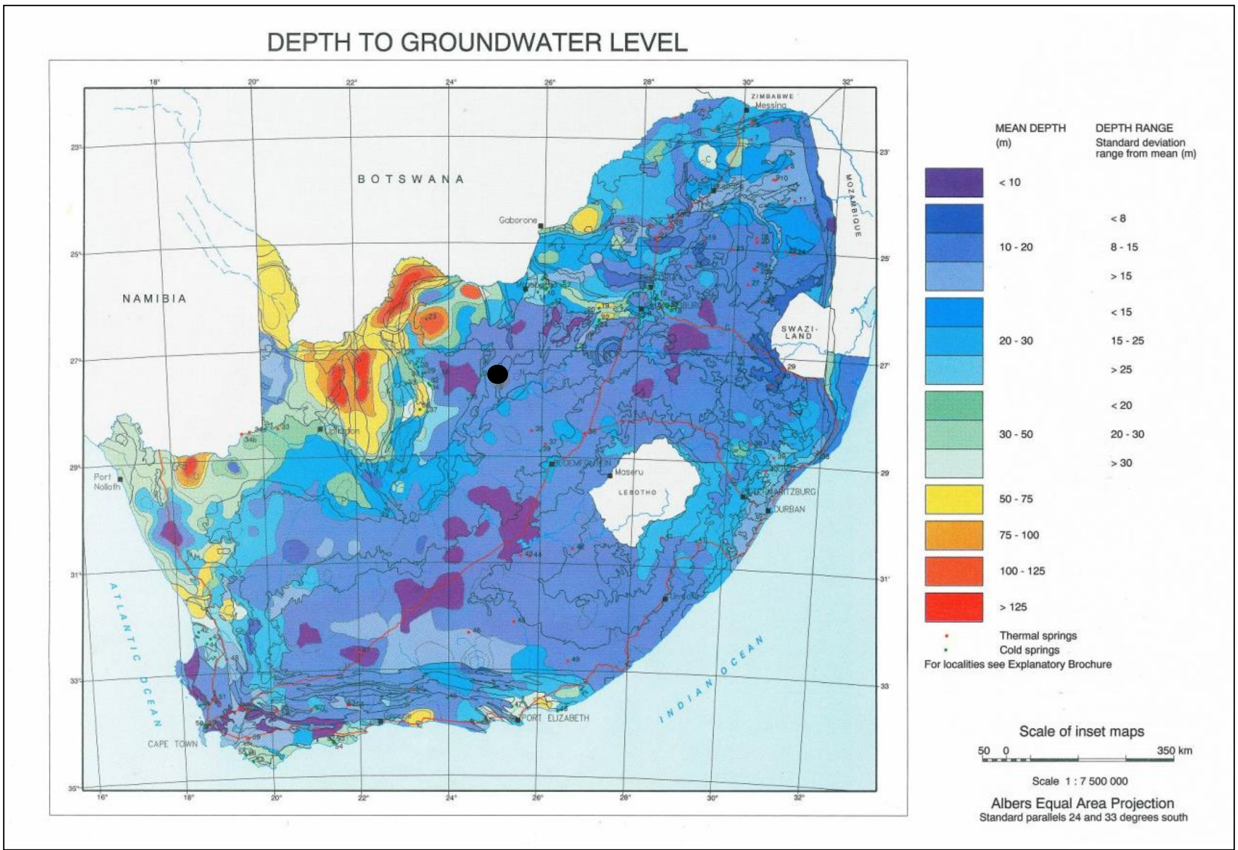

Figure 8: Depth of groundwater level (adapted from the Groundwater Resources of South Africa Map, DWA, 1995). Site location indicated with black circle.

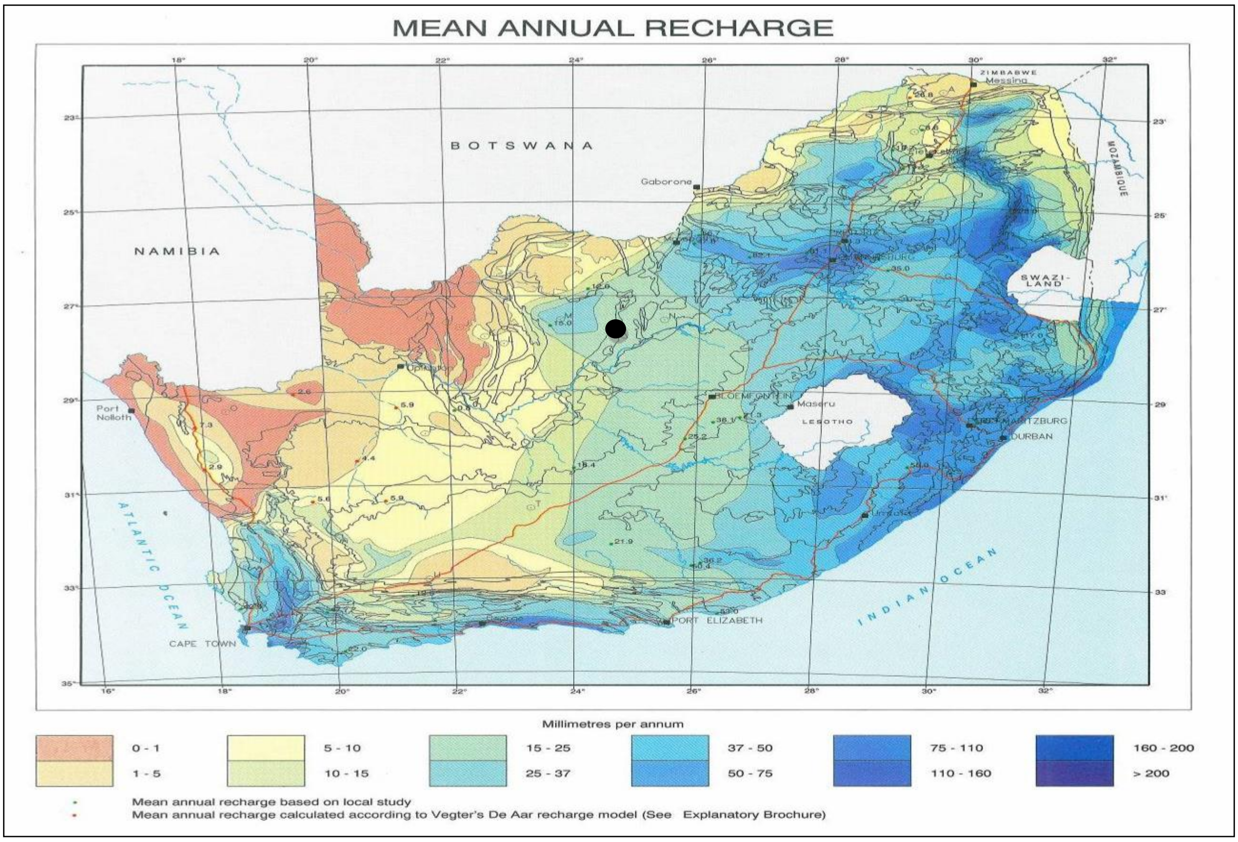

Figure 9: Mean annual recharge (adapted from the Groundwater Resources of South Africa Map, DWA, 1995). Site location indicated with black circle.

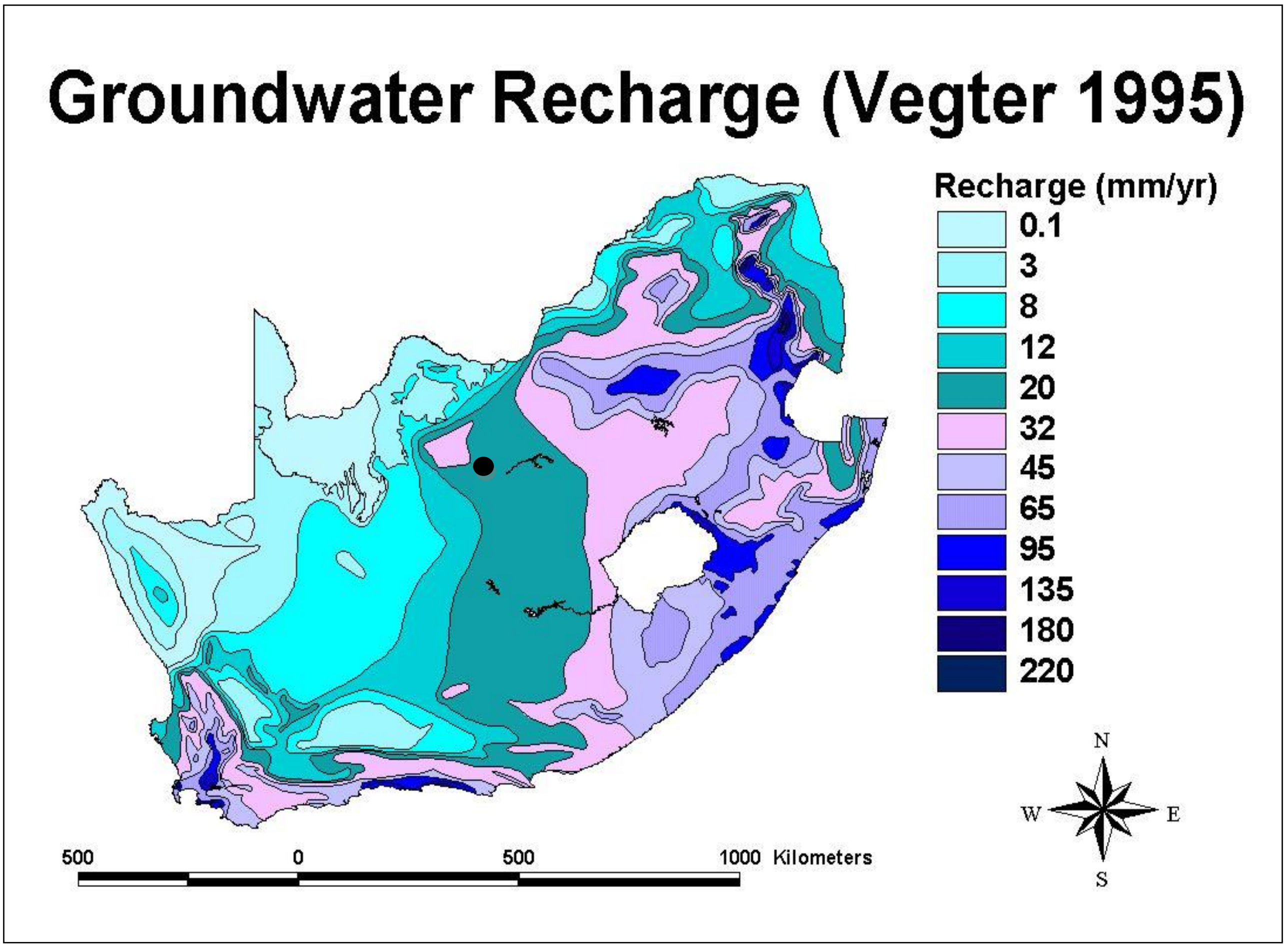

Figure 10: Groundwater recharge estimation map (Vegter, 1995). Site location indicated with black circle.

3 POTENTIAL POLLUTION SOURCES AND SENSITIVE AREAS

It is not expected that the project will have any negative impact on surface water resources, including the wetland located to the north of the site and the Harts River passing to the west of the site. These surface water resources are both located further than 300m away from the proposed site and no sensitive water resources are thus located on or near the proposed site. Therefore, if the stormwater system is correctly designed, constructed and maintained and stormwater is management according to the design and good housekeeping of the fuel station, including all associated areas thereof, is implemented it is not foreseen that there should be any negative impacts on these surface water features.

Groundwater resources should always be regarded as sensitive and should therefore be protected. Fuel stations, especially fuel stations with underground storage tanks poses risk of pollution to groundwater resources if the correct design, construction, mitigation, management and monitoring of these tanks, bunds, monitoring systems and aquifers are not implemented from the planning stages to the operation phase and until the end of life of the facility. Therefore, it is crucial that the engineer appointed to design the fuel station and storage tanks and bunds ensures that underground bunds are designed and constructed with impermeable materials to keep groundwater out of the vicinity of the tanks and that the aquifer is protected from any spills from storage tanks. Additionally, consideration should be given to the correct liners to be installed prior to construction of the underground bunds.

Further to the above, priority should be given to always clean any spill and/or material which may cause pollution of water from the surface immediately after it is noticed or reported to prevent seepage of pollutants into the groundwater and/or entering groundwater through stormwater which is contaminated.

4 SITE ASSESMENT

A site assessment and observation was conducted by Turn 180 on 29 October 2022. The objective of the site assessment was to establish groundwater level depths at existing boreholes on and around the proposed development site and to sample water from these resources for chemical analysis. A total number of 3 boreholes were identified and visited of which 2 were sampled and measured. One borehole were obstructed and could not be accessed. Borehole locations can be viewed in Figure 6. The groundwater level of the borehole on the development footprint was 3.54 mbgl.

Table 2: Table showing site assessment data

Borehole ID	Farm/ Erf	Coordinates		Static Water Level (mbgl)	Collar Height (m)	Equipped	Use	Sampled
		Lat	Long					
BH1	53	-27,7861	24,7203	2,63	0,5	No	None	Yes
BH2	312	-27,7899	24,71821	3,64	0,1	Solar	Potable	Yes

4.1 SITE ASSESMENT PHOTOS

Figure 11: Old borehole and pump adjacent to the proposed site

Figure 12: Image of BH 1

Figure 13: Image of the canal sampled

5 IMPACT ASSESSMENT, MANAGEMENT AND MITIGATION MEASURES

For the purposes of the assessment of the impacts on groundwater resources emanating from the construction and establishment of a fuel station the assessment will not be done for the planning phase as it is expected that no physical disturbance will occur in this phase, apart from test-pits being excavated as part of the geotechnical investigation.

Impact Identification:

The following impacts may occur during Phases 2 and 3 of the project:

Groundwater:

- Impact on groundwater quantity:
  - Abstraction and use of groundwater.
  - Decanting of groundwater during pitting and trenching.
- Impact on groundwater quality:
  - Spillage of hydrocarbons and other potentially hazardous substances from construction and other vehicles.
  - Leakage of underground storage tanks, pipes and bunds into the groundwater.

5.1 ASSESSMENT METHODOLOGY

The main objective of the impact assessment process will be to assess and quantify the potential impacts that were identified by the project team.

The concept of "*significance*" is at the core of impact identification, evaluation and decision-making during the assessment process and can be differentiated into impact magnitude and impact significance. Impact magnitude is the measurable change (i.e., intensity, duration and likelihood), while impact significance is the value placed on the change by different affected parties (i.e., level of acceptability) (DEAT, 2002).

The environmental significance assessment methodology is based on the following determination:

Environmental Significance = Overall Consequence x Overall Likelihood

5.1.1 Determination of Consequence

Consequence analysis is a mixture of quantitative and qualitative information and the outcome can be positive or negative. Several factors can be used to determine consequence. For the purpose of determining the environmental significance in terms of consequence, the following factors were chosen:

- Severity/Intensity,
- Duration and
- Extent/Spatial Scale.

Each factor is assigned a rating of 1 to 5, as described below.

5.1.2 Determination of Severity

Severity relates to the nature of the event, aspect or impact to the environment and describes how severe the aspects will impact on the biophysical and socio-economic environment.

Table 3: Rating of Severity

Type of criteria	**Rating**				
	1	**2**	**3**	**4**	**5**
Quantitative	0-20%	21-40%	41-60%	61-80%	81-100%
Qualitative	Insignificant / Non-harmful	Small / Potentially harmful	Significant / Harmful	Great / Very harmful	Disastrous Extremely harmful
Social / Community response	Acceptable / I&AP satisfied	Slightly tolerable / Possible objections	Intolerable / Sporadic complaints	Unacceptable / Widespread complaints	Totally unacceptable / Possible legal action
Irreversibility	Very low cost to mitigate / High potential to mitigate impacts to level	Low cost to mitigate	Substantial cost to mitigate / Potential to mitigate	High cost to mitigate	Prohibitive cost to mitigate / Little or no mechanism to

Type of criteria	Rating				
	1	**2**	**3**	**4**	**5**
	of insignificance / Easily reversible		impacts / Potential to reverse impact		mitigate impact Irreversible
Biophysical (Water quantity and quality, waste production, fauna and flora)	Insignificant change / deterioration or disturbance	Moderate change / deterioration or disturbance	Significant change / deterioration or disturbance	Very significant change / deterioration or disturbance	Disastrous change / deterioration or disturbance

5.1.3 Determination of Duration

Duration refers to the amount of time that the environment will be affected by the event, risk or impact, if no intervention e.g., remedial action takes place.

Table 4: Rating of Duration

Rating	Description
1: Low	One month
2: Low-Medium	Between 1 and 3 months (Quarter)
3: Medium	3 months to 1 year
4: Medium-High	1 to 10 years
5: High	More than 10 years

5.1.4 Determination of Extent/Spatial Scale

Extent refers to the spatial influence of an impact. It will be: a) limited to the site and its immediate surroundings; b) extending to the surrounding local area, c) regional (will have an impact on the region) c) national (will have an impact on a national scale); or d) or international (impact across international borders).

Table 5: Rating of Extent

Rating	Description
1: Low	Immediate, fully contained area
2: Low-Medium	Surrounding area
3: Medium	Regional
4: Medium-High	National
5: High	International

5.1.5 Determination of Overall Consequence

Overall consequence is determined by adding the factors determined above and summarised below, and then dividing the sum by 3.

Table 6: Example of calculating Overall Consequence.

Consequence	Rating
Severity	Example 4
Duration	Example 2
Extent	Example 4
SUBTOTAL	10
TOTAL CONSEQUENCE:(Subtotal divided by 3)	3.3

5.1.6 Determination of Likelihood

The determination of likelihood is a combination of **Frequency** and **Probability**. Each factor is assigned a rating of 1 to 5, as described below.

5.1.7 Determination of Frequency

Frequency refers to how often the specific activity, related to the event, aspect or impact, is undertaken.

Table 7: Rating of Frequency

Rating	Description
1: Low	Once a year or once during operation / Life of Plant
2: Low-Medium	Once / more in 6 Months
3: Medium	Once / more a Month
4: Medium-High	Once / more a Week
5: High	Daily

5.1.8 Determination of Probability

Probability refers to how often the activity/event or aspect has an impact on the environment.

Table 8: Rating of Probability

Rating	Description
1: Low	Almost never / almost impossible
2: Low-Medium	Very seldom / highly unlikely
3: Medium	Infrequent / unlikely / seldom
4: Medium-High	Often / regularly / likely / possible
5: High	Daily / highly likely / definitely

5.1.9 Determination of Overall Likelihood

Overall likelihood is calculated by adding the factors determined above and summarised below, and then dividing the sum by 2.

Table 9: Example of calculating the Overall Likelihood.

Likelihood	Rating
Frequency	Example 4
Probability	Example 2
SUBTOTAL	6
TOTAL LIKELIHOOD (Subtotal divided by 2)	3

5.1.10 Determination of Overall Environmental Significance

Quantitative description or magnitude of Environmental Significance

The multiplication of overall consequence with overall likelihood will provide the environmental significance, which is a number that will then fall into a range of LOW, LOW-MEDIUM, MEDIUM, MEDIUM, MEDIUM-HIGH or HIGH, as shown in the table below.

Table 10: Determination of Overall Environmental Significance.

Significance or Risk	Low	Low-Medium	Medium	Medium-High	High
Overall Consequence X Overall Likelihood	1 - 4.9	5 - 9.9	10 - 14.9	15 – 19.9	20 - 25

Qualitative description or magnitude of Environmental Significance

This description is qualitative and is an indication of the nature or magnitude of the Environmental Significance. It also guides the prioritisations and decision-making process associated with this event, aspect or impact.

Table 11: Description of the Environmental Significance and the related action required.

Significance	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Impact Magnitude	Impact is of very low order and therefore likely to have very little real effect. Acceptable.	Impact is of low order and therefore likely to have little real effect. Acceptable.	Impact is real, and potentially substantial in relation to other impacts. Can pose a risk to I&AP.	Impact is real and substantial in relation to other impacts. Pose a risk to the I&AP. Unacceptable.	Impact is of the highest order possible. Unacceptable. Fatal flaw.
Action Required	Maintain current management measures. Where possible improve.	Maintain current management measures. Implement monitoring and evaluate to determine potential increase in risk. Where possible improve	Implement monitoring. Investigate mitigation measures and improve management measures to reduce risk, where possible.	Improve management measures to reduce risk.	Implement significant mitigation measures or implement alternatives.

5.2 GROUNDWATER

Construction Phase:

5.2.1 Groundwater quality

The following impacts may occur on the groundwater because of the construction activities:

- Groundwater contamination because of spillages of petrochemical substances from vehicles, equipment and machinery, paints, thinners and other cleaners, grease and other hydrocarbons to the soil and subsoil.
- Incorrect storage and disposal of hazardous waste on site.
- Spillage of sewage on site.
- Exposure of aquifer during excavation.

Activity	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Handling, transportation and use of hazardous substances and machinery and the storage and disposal of hazardous waste. **-** **NOT MITIGATED**	3	4	2	3	4	5	4.5	13.5
MITIGATED	2	1	1	1.33	2	5	3.5	4.7

The impact assessment above shows that the impacts will be "*MODERATE*" if no mitigation is implemented, and incidents are not managed correctly. However, is the correct mitigation and management measures are implemented the significance of the impacts will be "*LOW*". The mitigation and management measures proposed are the following:

- All potentially hazardous substances (i.e., diesel, oil, grease, paints, etc.) should be stored inside tanks with a bund. The bund should consist of a structure with an impermeable base and walls with the capacity to store 110% of the volume of the substance stored therein.

- All waste must be separated into different waste streams on site and must not be disposed of together.
- Hazardous waste should be separated and stored as follows:
  - Old oil should be drained into a steel tank or drum and should be collected by a registered service provider for recycling,
  - Oil filters should be drained of oil and stored inside a leakproof container with a lid. Oil filters should be removed by a registered contractor for recycling,
  - Oil rags should be stored inside a leakproof and covered bin and should be removed from site by a registered service provider for recycling.
  - Contaminated soil must be stored inside a leakproof bin and disposed of at a registered hazardous waste disposal site or treated and returned to the area. If the contaminated soil is treated the proof of the treatment and classification should be kept on site.
- Machinery and vehicles should be serviced, inspected, and repaired as required and on regular intervals to prevent spillages of petrochemical substances. No vehicles, equipment or machinery will be serviced on the site. If emergency repairs are necessary, a drip tray will be used and all hazardous waste will be removed from the site and disposed of by the responsible contractor.
- All equipment containing petrochemical substances (i.e., generators, transformers, etc.) must be stored on a drip tray or inside a bund to collect any leakage and to prevent groundwater contamination.
- Drip trays should be placed under all stationary vehicles and equipment including diesel tanker trailers to prevent leaking hazardous substances from polluting the groundwater.
- Incidents such as bursting hydraulic pipes or spills which may occur must be contained and cleaned immediately by removing the spilled substance and the contaminated soil and storing it inside a drum or container as described above.
- Care should be taken when transporting and handling (i.e., refuelling) petrochemical or other potentially hazardous substances and spillage should be prevented.
- Oil spill kits will be available on the site during the construction phase of the project.

The contractors should consider that prevention of spillage is more cost effective and sustainable than the management of spills or incidents as incidents is extremely costly to remedy, rehabilitate and the cost of disposal of contaminated soil and products are very high.

Activity	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Exposure and contamination of groundwater aquifer during excavation. **-** **NOT MITIGATED**	2	2	1	1.7	1	5	2.5	4.2
MITIGATED	1	1	1	1	1	5	2.5	2.5

Given the water level measured at the BH2 and the test pits of the geotechnical investigation it is likely that water will seep into voids and/or trenches excavated for foundation work and underground storage tanks. However, the impact on the loss of groundwater will be limited if the water is pumped from the voids and reused on site during construction activities.

It is expected that the significance of the impact of contamination of groundwater due to exposure of the aquifer during excavation will be "*LOW*". The pumping and reuse will result in loss of water. However, the impact on the resource is not expected to be significant and should be low if water is used sparingly.

It is recommended that the project design engineers make provision and consider the management of groundwater seepage during pitting and trenching to preserve water and not exceed the depths required to obtain the desired structural objectives.

5.2.2 Groundwater quantity

The construction activities at the fuel station may have an impact on the quantity (i.e., volumes) of groundwater if the activities will either use groundwater for construction or remove seepage from pits, trenches or voids.

Activity	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Abstraction and use of groundwater - NOT MITIGATED	3	4	2	3	4	4	4	12
MITIGATED	2	3	2	2.33	2	4	4	9.3

The significance of the impact on the groundwater quantity without mitigation is "*MODERATE*". This impact can be mitigated to lower the significance to "*LOW-MODERATE*".

The following mitigation and management measures must be implemented if groundwater will be used:

- A Water Use License (**"WUL"**) should be applied for with the DWS for the water use in terms of Section 21 of the National Water Act, 1998 (Act No. 36 of 1998) (**"NWA"**) if groundwater will be used abstracted and used at the fuel station. The development area is in the C33A quaternary catchment of the WMA5 (Vaal). Therefore, according to the "*Revision of the General Authorisation for the taking and storing of water*" of 2 September 2016 the applicant may apply for a general authorised water use of 75m^3/hectare/annum. Furthermore, to apply for a water use which should be generally authorised the abstraction point must be further than 100m from a watercourse and 500m from a wetland and cannot exceed 40 000m^3/annum.

- If groundwater is abstracted the volume of water abstracted and used should be measured using flow meters and these volumes must be documented monthly.

- No water should be wasted and infrastructure (i.e., pumps, pipes, holding tanks, etc.) should be inspected and monitored and leaks should be repaired immediately.

- All measures should be implemented to ensure that the water system functions efficiently, and that evaporation and other losses are limited.

OPERATIONAL PHASE:

5.2.2.1 Groundwater quality

The following impacts may occur on the groundwater during the operational phase:

- Groundwater contamination because of spillages of petrochemical substances from vehicles, equipment and machinery, paints, thinners and other cleaners, grease and other hydrocarbons to the soil and subsoil.
- Incorrect storage and disposal of hazardous waste on site.
- Spillage of sewage from underground conservancy tanks.
- Leaking underground storage tanks, pipes and bunds and leaking pumps.

Activity	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Refuelling of vehicles, parking of vehicles and storage of petrochemicals and other hazardous substances above-ground. - NOT MITIGATED	3	4	2	3	4	5	4.5	13.5
MITIGATED	1	1	1	1	2	5	3.5	3.5

The impact assessment above shows that the impacts will be "*MODERATE*" if no mitigation is implemented, and incidents are not managed correctly. However, if the correct mitigation and management measures are implemented the significance of the impacts will be "*LOW*". The mitigation and management measures proposed are the following:

- The refuelling and vehicle parking areas should preferably be paved to limit seepage of petrochemical and other hazardous substances into the groundwater if spillage occurs.
- All petrochemical and other potentially hazardous substances and hazardous waste should be bunded. The bund should:
  - Consist of an impermeable surface/base with impermeable walls which can contain 110% of the stored substance or waste.
  - Have a controlled outlet valve with the open and lose positions clearly marked. This valve must be equipped with a drainage sump to collect any spills during the

drainage of stormwater from it. Stormwater from the bund will not be allowed to drain into the surrounding environment.

- All waste must be separated into different waste streams on site and must not be disposed of together in bins or containers.
- Hazardous waste should be separated and stored as follows:
  - Old oil should be drained into a steel tank or drum and should be collected by a registered service provider for recycling,
  - Oil filters should be drained of oil and stored inside a leakproof container with a lid. Oil filters should be removed by a registered contractor for recycling,
  - Oil rags should be stored inside a leakproof and covered bin and should be removed from site by a registered service provider for recycling.
  - Contaminated soil must be stored inside a leakproof bin and disposed of at a registered hazardous waste disposal site or treated and returned to the area. If the contaminated soil is treated the proof of the treatment and classification should be kept on site.
- All equipment containing petrochemical substances (i.e., generators, transformers, etc.) must be stored on a drip tray or inside a bund to collect any leakage and to prevent groundwater contamination.
- Drip trays will be available on site to be placed under supplier trucks during the refuelling of storage tanks.
- Spill kits will always be available on the site during the operational phase of the project and will be used to clean and dispose of petrochemical and other potentially hazardous spills immediately.
- No dirty/contaminated water will be allowed to drain from the site into the surrounding environment. Clean water must be diverted around the site into the natural drainage areas.

Activity	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Storage of petrochemical and other	4	4	2	3.3	4	5	4.5	14.85

hazardous substances, including sewage underground. **-** **NOT MITIGATED**								
MITIGATED	2	1	1	1.3	2	5	3.5	4.6

The storage of petrochemical and other potentially hazardous substances can cause significant groundwater pollution and affect the resource if not managed correctly. This is evident in the above impact assessment which shows that the impact is on the high-end of "*MODERATE*" and even "*MODERATE-HIGH*" if no mitigation and monitoring is implemented. However, with the correct mitigation, management and monitoring these impacts can be reduced to "*LOW*".

The mitigation, management and monitoring must include the following as a minimum:

- The design engineer will design the appropriate underground impermeable bunds to contain all petrochemical storage tanks and will incorporate the necessary liner and compaction required to contain the bunds. No water will be allowed to enter the bunds and no liquid substance will be allowed to seep from the bunds.
- The engineer will be on site for inspection and supervision during the installation of the bunds and will do all the necessary quality inspections, reporting and signoff.
- After installation of the bund, a final inspection will be done to ensure that all bunds are leak-proof and impermeable and the engineer will sign off on the condition of the bunds.
- If required and necessary the engineer will design drainage measures to keep shallow groundwater away from the fuel station.
- The storage tanks will be installed under supervision of the engineer. These tanks will be pressure tested after installation and must be approved by the engineer prior to use.
- All pipes will be tested for leaks prior to completion and will be approved by the engineer.
- The applicant will ensure that all necessary and mandatory substance volume measurements and leak detection systems are installed, maintained, monitored and logged throughout the

lifetime of the fuel station. These leak detection devices and systems will be installed on both the tanks and bunds.

- The applicant will drill a borehole near the fuel station for groundwater sampling to occur quarterly to test water for pollutants. Two (2) additional borehole upstream and downstream of the fuel station will be identified and sampled to provide baselines for detection. The results of samples taken by Turn 180 in 2022 must also be considered as baseline data to which water must comply.
- Loss of unaccounted substance will immediately be reported to authorities such as the Department of Energy, Department of Environmental Affairs, Department of Water and Sanitation and samples of all monitoring boreholes will be taken.
- Conservancy tanks will be designed according to the need and will have sufficient capacity for the storage of sewage.
- A log sheet will be available to monitor the levels of conservancy tanks daily to ensure that they do not overflow and spill into the environment.
- The water and sewage system will be monitored and leaking pipes and toilets will be repaired immediately to avoid unnecessary overflowing of conservancy tanks and loss of clean water.
- A contractor will be appointed to service conservancy tanks and remove sewage from them.

5.2.2.2 Groundwater quantity

The operation of a fuel station will require water for customers and for washing and servicing of vehicles. It is unclear at the time of this report whether the applicant will utilise groundwater, scheme water or a combination of both. This will be confirmed before commencement of operations and will be authorised.

The main impact will be loss of groundwater due to use thereof and spillage.

Activity	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Use of groundwater at the fuel station and associated areas.	3	3	2	2.7	3	5	4	9.4

- **NOT MITIGATED**								
MITIGATED	1	1	1	1	1	5	2.5	2.5

The significance of the impact on the groundwater quantity without mitigation is "*LOW-MODERATE*". This impact can be mitigated to lower the significance to "*LOW*".

The following mitigation and management measures must be implemented if groundwater will be used:

- The applicant will apply for a WUL with the relevant authority (i.e., DWS) prior to abstraction and use of groundwater at the fuel service station. If the volume of groundwater to be abstracted will be more than the generally authorised volumes the applicant will appoint a suitably qualified geohydrologist to conduct a yield test to determine the rate of recovery and recharge of the aquifer and thereby confirm whether the volumes to be abstracted will not significantly impact on the resource.

- All leaking pipes, taps and toilettes will be repaired immediately to prevent wastage of water.

- Water used at the fuel service station will be measured and logged weekly.

6 CONCLUSIONS AND RECOMMENDATIONS

- It is known that the storage of any potentially hazardous substances underground may lead to pollution of groundwater if not mitigated and managed correctly. Therefore, the applicant should ensure that all measures are taken during the construction phase of the project to correctly compact pits, install bunds according to engineer specification, install all leak detection devices and equipment and inspect the tanks prior to use.
- In the event of shallow groundwater aquifers and excessive seepage to underground voids the engineer will ensure that drainage be designed and installed to accommodate the seepage and ensure that no water seeps into the bunded areas.
- A groundwater monitoring programme should be implemented prior to installation of underground tanks and operation. The programme must confirm all groundwater sampling locations and the interval of groundwater monitoring to be conducted. It is highly recommended that the sampling interval not exceed quarterly intervals.
- The applicant must apply for a WUL if they will use groundwater at the fuel service station.