WSMLESHIKA
CONSULTING (PTY) LTD

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M&M TRANSPORT DIESEL DEPOT

Hydrogeological Evaluation, Portion 1 Erf 6154, Pietersburg Extension 8, Polokwane Local Municipality, Limpopo

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HYDROGEOLOGICAL EVALUATION

HYDROGEOLOGY

04

HYDROGEOLOGICAL EVALUATION FOR THE PROPOSED M&M TRANSPORT DIESEL DEPOT ON PORTION 1 ERF 6154, PIETERSBURG EXTENSION 8, POLKWANE LOCAL MUNICIPALITY, LIMPOPO PROVINCE

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1 INTRODUCTION

This report gives the results of a Hydrogeological evaluation conducted for the proposed M&M Transport Diesel depot on portion 1, erf 6154 Pietersburg extension 8 located at 56 Antimoon Street Laboria Polokwane in the Polokwane Local Municipality of Limpopo Province. The proposed project consists of the installation of an 83 000 litre ($83m^3$) underground tank for the storage and handling of dangerous goods (diesel) to be used by M&M Transport for refuelling their trucks.

The hydrogeological conditions pertaining to the area and potential impact of the diesel storage facilities on the ground water resources are based on existing borehole information, past reports in the area, water quality analyses and the experience of **WSM Leshika (Pty) Ltd** in the area.

2 TERMS OF REFERENCE

The proposal submitted by **WSM Leshika (Pty) Ltd** was approved by Tecoplan Environmental and M&M Transport whom instructed **WSM Leshika (Pty) Ltd** to proceed with the investigation

3 SCOPE OF WORK

The purpose of the investigation was to assess the impact of the M&M Transport Diesel depot development on the groundwater resource.

WSM Leshika (Pty) Ltd was tasked with providing:

- A list of existing available borehole information
- Evaluation of the existing use, ground water potential and water quality
- Evaluation of the impact the proposed development is expected to have on the groundwater resources

- Recommendations on monitoring boreholes and mitigation measures

4 SITE DESCRIPTION

4.1 Locality

The study area is situated at 56 Antimoon Street located in the industrial area of Laboria 4km north of Polokwane city centre (Figure 1 &2). The erf has an approximate size of 7600m^2 (0.76 Ha) based on Google Earth measurements. The approximate centre coordinates of the investigated area are as follows (Datum: WGS84, Decimal Degrees):

- Latitude: -23.871279°
- Longitude 29.443744°

4.2 Climate

According to the Köppen Climate classification system Polokwane has a Semi-Arid Climate. Midday temperatures range between 27°C- 28°C in the summer months. Winters are mild to warm with day temperatures ranging between 19°C - 20°C with an average night temperature of 4.4°C. Mean annual precipitation (MAP) is 468mm (average for Catchment area), with a summer rainfall season occurring in the months of October to March.

Rain station 67784 is the nearest station to the study area (Figure 3) that has rainfall data available.

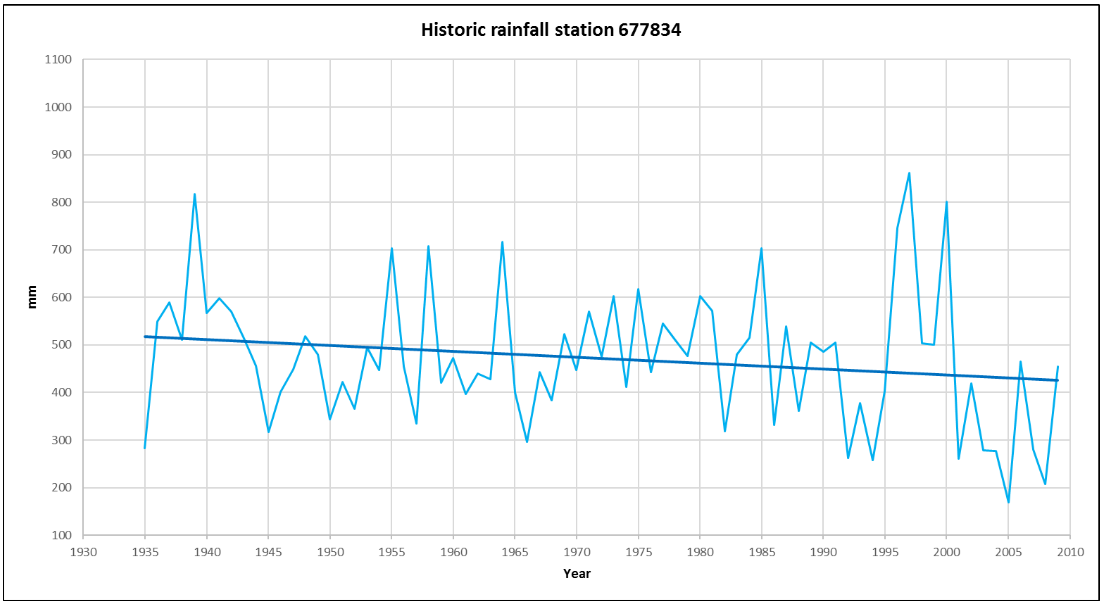
Monthly rainfall data between the years 1989-2009 are available and indicates an average of 429.6mm per annum for that time period. According to WR2012, rainfall season is between October and March during the summer months. Rainfall is low during the winter months of May to September. (Table 1)

Yearly average rainfall data between the years 1935-2009 are available and plotted on graph 1. Alternating dryer and wetter yearly rainfalls are observed. A Downward rainfall trend line is also observer over the time period from 1951 - 2009. No rainfall data are available between the years 2010 to present 2021 for the rainfall station however it is known that the area have been subjected to lower rainfall for the past 4 years with only the last year being a good rainfall season, (Graph 1).

Table 1: Average Monthly Rainfall for Station 677834

YEAR	MONTHS											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1989	31.0	108.0	25.0	35.7	0.0	27.6	0.0	8.5	0.0	65.5	136.6	67.5
1990	43.9	54.4	73.0	42.5	5.5	0.0	3.0	0.0	0.0	19.0	149.7	94.5
1991	135.5	137.0	56.0	8.7	19.7	8.5	0.0	0.0	0.0	7.5	77.0	55.5
1992	95.8	14.5	25.4	14.0	0.0	0.0	0.0	0.0	0.0	10.0	56.0	46.0
1993	10.5	52.0	33.0	66.0	0.0	0.0	0.0	0.0	27.0	8.0	108.5	72.5
1994	35.5	15.5	36.2	31.5	0.0	0.0	0.0	2.0	2.5	25.5	56.9	52.7
1995	70.8	13.8	127.0	50.0	2.0	0.0	0.0	0.9	0.0	16.4	83.4	39.0
1996	220.1	196.1	69.2	11.6	74.6	0.0	32.6	0.0	7.6	20.0	53.1	61.5
1997	230.1	159.0	224.0	31.0	40.0	0.0	0.0	0.0	13.8	30.4	121.5	11.5
1998	50.8	32.7	93.2	90.0	0.0	0.0	0.0	0.0	9.0	54.3	79.5	94.0
1999	198.0	33.5	21.5	4.5	12.0	4.0	0.0	0.0	2.1	29.0	116.0	80.0
2000	109.5	280.5	60.7	68.0	20.0	58.5	0.0	0.0	0.0	62.0	65.0	76.5
2001	5.0	32.5	50.0	35.0	13.0	0.0	0.0	0.0	0.0	26.5	64.9	34.0
2002	115.0	23.0	39.6	14.0	18.0	31.0	0.0	0.0	34.0	38.5	76.4	30.0
2003	100.5	18.5	19.0	15.0	0.0	13.0	0.0	0.0	0.0	5.0	65.3	42.0
2004	76.4	93.0	32.2	13.5	0.0	0.0	0.0	0.0	0.0	15.0	11.5	35.1
2005	17.5	45.5	18.0	9.5	0.0	0.0	0.0	0.0	14.8	0.0	36.7	26.7
2006	24.3	113.3	78.3	10.5	2.5	0.0	0.0	0.0	0.0	24.2	73.9	138.4
2007	17.9	13.0	41.2	18.6	0.0	2.5	0.0	0.0	16.4	43.4	84.5	43.0
2008	28.0	21.0	44.2	28.2	6.5	0.0	0.0	0.0	0.0	19.0	26.3	34.5
2009	19.4	88.0	82.4	0.0	33.1	15.0	6.5	0.0	8.2	47.5	74.0	80.0
Aver. Monthly Rain (mm)	**77.9**	**73.6**	**59.5**	**28.5**	**11.8**	**7.6**	**2.0**	**0.5**	**6.4**	**27.0**	**77.0**	**57.9**
Aver. Yearly Rain between 1898 to 2009 (mm)												**429.6**

Graph 1: Average Yearly Rainfall for Station 677834



Mean annual S-Pan evaporation (MAE) is 2005 mm (WR2005).

4.3 Physiography and drainage

According to the Terrain Morphology Map of South Africa (Kruger, 1983), regional topography can be described as (B9) Plains with moderate relief (B, 30-210m), moderately undulating plains (9). Drainage density is low-medium (0–2 km/km^2) and stream frequency is low-medium

(0-6 streams/km^2). Polokwane is situated on the broad terrain pattern of the Limpopo Plain. The project area is reworked and generally flat with a gentle North-western slope and has an elevation of 1235metres above mean sea level (mamsl).

The Property is in the A71A Quaternary catchment area. On site drainage is predominantly in a north-western direction towards the Sand River. The Sand River is the main drainage feature of the A71A quaternary catchment area and flows in a north-eastern direction (Figure 4).

4.4 Soils and Vegetation

The property lies within the Northern plateau Ecoregion and Central Bushveld bioregion with a semi-arid climate. Natural vegetation consists of Pietersburg plateau grassveld (Figure 5) however the natural vegetation has been removed entirely from the property. According to the Water research commission (2012) soil template map, the property area is underlain by plinthic catena: eutrophic; red soils not widespread, upland duplex and margalitic soils rare (Figure 6).

From the Geotechnical report conducted by RockSoil Consult the Soil horizons consist of:

Engineering Fill, Topsoil/colluvium horizon, a pebble marker horizon and reworked residual gneiss. Seepage was not encountered during the shallow soil investigation however signs of seasonal shallow seepage conditions in the form of ferricrete were encountered in the profiles therefore severe shallow seepage is expected during or after heavy and/or continuous downpours.

5 REGIONAL GEOLOGY

According to the 1:250 000 scale 2328 Pietersburg Geological series the property is underlain by: Leucocratic migmatite and gneiss, grey and pink hornblende-biotite gneiss, grey biotite gneiss, minor muscovite-bearing granite, pegmatite and gneiss of the Hout River Gneiss (Rhr). To the east to south of the site lies Talc-chlorite and amphibolite-chlorite schist, amphibolite, serpentinite and some iron formation of the Mothiba formation of the Pietersburg group (Zpm). Northeast to southwest trending dolerite dykes are present within the underlaying geology. See Figure 7.

6 HYDROGEOLOGICAL EVALUATION

6.1 Hydrocensus

No boreholes are located on the development property. Four boreholes were located on the neighbouring properties namely BH1, BH2, BH3 and BH4. Borehole BH1 was the nearest borehole located to the property and therefore sampled and tested for water quality analysis by a SANAS accredited laboratory. The locations of the boreholes are given in figure 8 and the borehole information is given in table 2.

Table 2: Borehole information

BH No	COORDINATES		BH DEPTH (mbgl)	WATER LEVEL SWL (mbgl)	EQUIPMENT	SAMPLE	Notes	OWNER	ELEVATION (m) from Google Earth
	Latitude	Longitude							
BH1	-23.871784	29.440971	30	±10 Root blockage	Electric Submersible	Chemistry, BTEX and TPH	Domestic and taxidermy use 2500 l/day; Water strike 18mbgl	Safari Taxidermy 0152932674 info@safaritaxidermy.co.z	1231
BH2	-23.871620	29.440380	40	Sealed and Burried	Electric Submersible	-	Domestic use 2500 l/day; Water strike 29mbgl	Marlen Industries 0152930363	1230
BH3	-23.872450	29.440200	42	14.0	None	-	Drilled 2020 for dewatering of Marlen factory in wet season	Marlen Industries 0152930363	1231
BH4	-23.872330	29.440410	42	14.1	None	-	Drilled 2020 for dewatering of Marlen factory in wet season	Marlen Industries 0152930363	1231

Boreholes BH1, BH2, BH3 and BH4 are located west of the property and slightly downstream. The boreholes are all located in a 50m radius of each other and therefore might have an influence on each other when abstraction occurs.

Borehole BH1 is used as domestic and taxidermy use with an approximate daily abstraction of 2500 litres. A water level could not be obtained due to the probe being blocked at 10m depth by roots. According to the owner the borehole had a water strike at 18mbgl and is 30m deep. Water samples were taken from borehole BH1 to test for Chemistry, BTEX and TPH, see section 6.7.

Borehole BH2 is used for domestic purposes with an abstraction of approximately 2500litres per day. A water level could not be obtained due to the borehole being sealed shut and buried for theft prevention. According to the owner the borehole had a water strike at 29mbgl and is 40m deep.

Borehole BH3 and BH4 were drilled in 2020 for dewatering purposes during the rainy season, thus supporting the shallow seasonal seepage conditions mention in the Geotechnical report. Both boreholes are 40m deep and have water levels of 14.0mbgl and 14.1mbgl respectively.

The boreholes are unequipped at present.

It is expected that the groundwater flow direction will mimic a subdued form of the surface topography which is in a generally north-western direction.

Photo 1: BH1

Photo 2: BH3

Photo 3: BH4

6.2 Regional Aquifer

According to the Water research commission (2012) Aquifer map the property is underlain by Intergranular and Fractured aquifers consisting of the lithologies stated in Section 5. The expected borehole yields are given as >5.0 ℓ/s. (Figure 9)

6.3 Regional Hydrogeology

Groundwater is associated with zones of weathering and the transition zone between weathered and fresh rock. Knowing the underlying geology to be Gneissic rocks with dolerite dykes in places, groundwater and Groundwater flow occurs in joints and fractures as well as geological boundaries between the dolerite intrusions. These structures act as preferential pathways for groundwater flow. Deeper weathering occurs along drainage lines. The dolerite dyke intrusions cause fracturing in the surrounding gneisses with these fractured zones being more vulnerable towards weathering and therefore can also be possible water bearing structures.

Borehole data was obtained from the NGA (National Groundwater Archive) as well as the GRIP database for a radius of 1.5km around the property (Table 3).

Table 3: NGA and GRIP Borehole information

ID	Latitude	Longitude	Measurement Date and Time	Water Level (mbgl)	Depth (mbgl)	Water Strike (mbgl)	Blow Yield Value (l/s)	Abstraction m3/day	Class
2329CD00048	-23.8841	29.44977	1982/03/18 12:38	10.08	20.08	-	-	-	-
H16-1819	-23.8829	29.45157	-	-	-	-	-	-	-
36274	-23.881	29.44893	1989/02/01 09:00	6.63	46	27	15	-	-
36273	-23.881	29.45088	1989/02/01 12:00	5.56	66	35	3	-	-
036273A	-23.8667	29.44566	1998/05/11 12:00	15.64	26	-	-	-	-
H04-2129	-23.8746	29.44476	2004/07/22	14.75	71.18	-	-	12.96	CLASS II

From the NGA and GRIP database groundwater levels are shallow, water strikes are moderate and yields are high.

6.4 Aquifer storage

The aquifer storage is difficult to determine. As the aquifer type is known to be a weathered and fractured aquifer, the storage is estimated from the Groundwater Resources Assessment Study (GRA II) as about 0.00269 for the weathered zone and 0.000293 for the fractured zone for quaternary catchment A71A. The thickness of the weathered portion is estimated to be 40m and the fractured zone 117m.

6.5 Recharge

Recharge can be described as the replenishment from rainfall to the aquifers. Information from the Groundwater Resources Assessment Study (GRA II) gives the annual average aquifer recharge as 14.60mm/annum.

6.6 Water Quality

Water samples was taken from borehole BH1 and submitted to a SANAS accredited laboratory to analyse for the main physio-chemical properties, BTEX (Benzene, Toluene, ethylbenzene and xylenes) and TPH (Total Petroleum Hydrocarbon). Borehole BH1 is located slightly downstream and 250m west of the development property. Future quality analysis will need to be sampled from an onsite monitoring borehole.

The water samples were taken on 22nd of October 2021 and submitted to the lab on the same day, the results summarised in table 4, 5 and 6.

Table 4: Water Chemistry for BH1

ANALYSES	UNIT	BH1	CLASSIFICATION				
		2021/09/22	Class 0 IDEAL	Class I GOOD	Class II MARGINAL	Class III POOR	Class IV UNACCEPTABLE
PHYSICAL AND AGGREGATE PROPERTIES							
pH	pH units	7.2	5.0 - 9.5	4.5-5 or 9.5-10	4-4.5 or 10-10.5	3-4 or 10.5-11	< 3 or > 11
Conductivity	mS/m	88.4	< 70	70 - 150	150 - 370	370 - 520	> 520
TDS	mg/l	574	< 450	450 - 1000	1000 - 2400	2400 - 3400	> 3400
Bicarbonate alkalinity	CaCO3	225.8					
Carbonate alkalinity	CaCO3	0.0					
HARDNESS							
Total Hardness	CaCO3	284.74	< 200	200 - 300	300 - 600	> 600	
Ca - Hardness	CaCO3	125.25					
Mg - Hardness	CaCO3	159.49					
METALS							
Aluminium (Al)	mg/l	0.01					
Arsenic (As)	mg/l	<0.03	< 0.01	0.01 - 0.05	0.05 - 0.2	0.2 - 2	> 2
Calcium (Ca)	mg/l	50.10	< 80	80 - 150	150 - 300	> 300	
Copper (Cu)	mg/l	0.01	< 1	1 - 1.3	1.3 - 2	2 - 15	> 15
Iron (F)	mg/l	<0.01	< 0.5	0.5 - 1	1 - 5	5 - 10	> 10
Magnesium (Mg)	mg/l	38.90	< 70	70 - 100	100 - 200	200 - 400	> 400
Manganese (Mn)	mg/l	<0.01	< 0.1	0.1 - .4	0.4 - 4	4 - 10	> 10
Potassium (K)	mg/l	5.90	< 25	25 - 50	50 - 100	100 - 500	> 500
Sodium (Na)	mg/l	72.17	< 100	100 - 200	200 - 400	400 - 1000	> 1000
INORGANIC NON METALLIC CONSTITUENTS							
Chloride (Cl)	mg/l	98.00	< 100	100 - 200	200 - 600	600 - 1200	> 1200
Fluoride (F)	mg/l	0.45	< 0.7	0.7 - 1	1 - 1.5	1.5 - 3.5	> 3.5
Ammonium (NH_4 - N)	mg/l	<0.20					
Nitrate (NO_3 - N)	mg/l	7.66	< 6	6 - 10	10 - 20	20 - 40	> 40
Nitrite (NO_2 - N)	mg/l	<0.01	< 6	6 - 10	10 - 20	20 - 40	> 40
Orthophosphate (PO4 - P)	mg/l	<0.05	< 0.1	0.1 - 0.25	0.25 - 1	> 1	
Sulphate (SO4)	mg/l	57.31	< 200	200 - 400	400 - 600	600 - 1000	> 1000
Silica (Si)	mg/l	35.97					
WATER CLASS (CHEMISTRY)		CLASS I					
Sum Cations	meq/l	9.0300					
Sum Anions	meq/l	9.040306					

any value with a less than symbol (<) indicates that the value is below the detection limit for said test method

According to the test results the water quality from borehole BH1 has an overall **Class I** chemistry classification according to DWA Standards. The quality of the water can be considered as Good with only slightly elevated Nitrate, Hardness, Total Dissolved Solids which results in slight elevated Conductivity. All other constituents tested for resulted in ideal quality. (Table 4)

Table 5: BTEX for BH1

ANALYSES	UNIT	BH1
		2021/09/22
BTEX		
MTBE (Methyl tert-butyl ether)	ppb	**<100**
Benzene	ppb	**<10**
Toluene	ppb	**<10**
Ethylbenzene	ppb	**<10**
m+p Xylene	ppb	**<10**
o-Xylene	ppb	**<10**

Table 6: TPH for BH1

COMPOUND	UNIT	BH1
		2021/09/22
C8	ppb	<2.5
C9	ppb	<2.5
C10	ppb	<2.5
C11	ppb	<2.5
C12	ppb	<2.5
C13	ppb	<2.5
C14	ppb	<2.5
C15	ppb	<2.5
C16	ppb	<2.5
C17	ppb	<2.5
C18	ppb	<2.5
C19	ppb	<2.5
C20	ppb	<2.5
C21	ppb	<2.5
C22	ppb	<2.5
C23	ppb	<2.5
C24	ppb	<2.5
C25	ppb	<2.5
C26	ppb	<2.5
C27	ppb	<2.5
C28	ppb	<2.5
C29	ppb	<2.5
C30	ppb	<2.5
C31	ppb	<2.5
C32	ppb	<2.5
C33	ppb	<2.5
C34	ppb	<2.5
C35	ppb	<2.5
C36	ppb	<2.5
C37	ppb	<2.5
C38	ppb	<2.5
C39	ppb	<2.5
C40	ppb	<2.5
TPH (Total Petroleum Hydrocarbon)		
TOG (Total Oil and Grease)	mg/kg	**<1**

The BTEX (Benzene, Toluene, ethylbenzene and xylenes) (Table 5) and TPH (Total Petroleum Hydrocarbon) (Table 6) tests were done to give an indication of whether existing contamination occurs in the vicinity of the development and to serve as background and reference data for future studies and monitoring.

The BTEX and TPH tests results indicate no pollution occurring in the groundwater of BH1. It should be noted that BH1 is not directly downstream of the fuel depot and not owned by M&M Transport therefore a monitor Borehole will be required directly downstream of the proposed fuel storage tanks.

7 POTENTIAL CONTAMINATION OF GROUNDWATER

7.1 Sources of contamination

Groundwater contamination from the Diesel depot can occur from:

• Leaking underground diesel tanks (USTs).

• Leakage and spills of diesel and spills from storage tanks.

• Accidental spills and overfills from filler areas.

• Leaks from the pumps.

• Leakage and spills in the forecourt areas.

• Leakage of oils and grease.

7.2 Types of contamination

Groundwater contamination can occur in several distinct phases:

• Light non-aqueous phase liquids (LNAPLs).

• Dense non-aqueous phase liquids (DNAPLs).

• Dissolved constituents from LNAPLs and DNAPLs.

• Vapours emanating from LNAPLs.

7.2.1 LNAPLs

LNAPLS are Light non-aqueous phase liquids (LNAPLs) such as diesel and petrol that are less dense than water. LNAPLs are hydrocarbons that do not mix with water and exist as a separate phase.

Upon release to the environment, LNAPLs will migrate downward to the water table. If a small volume of LNAPL is released to the subsurface, it will move through the unsaturated zone where a fraction of the hydrocarbon will be retained in soil pores. If sufficient LNAPL is released, it will migrate until it encounters a physical barrier (e.g., low permeability strata) or is affected by buoyancy forces near the water table. Once the saturated zone is reached, the LNAPL may move laterally along the upper boundary of the water-saturated zone. Although principal migration may be in the direction of the maximum decrease in water-table elevation, some migration may occur initially in other directions.

Infiltrating precipitation and passing ground water in contact with residual or mobile LNAPL will dissolve soluble components and form an aqueous-phase contaminant plume dissolved in groundwater. The solubles are largely the BTEX component (Benzene, Toluene, Ethylbenzene, Xylene), which are a risk to health and the environment as they have harmful effects on the central nervous system. The BTEX component typically makes up 18% of petrol. Because they are the most volatile and most soluble, and less easily attached to organics in the soil, the BTEX component is the most mobile component of hydrocarbon spills.

In addition, volatilization may result in further spreading of contamination into the unsaturated zone above.

LNAPL constituents may exist in any of four phases within the subsurface (Plate 7-1):

- The LNAPL in its original state.
- Dissolved phase in groundwater.
- Gaseous phase in the unsaturated zone.
- Trapped in pore spaces in the saturated and unsaturated zone.

Since they migrate predominantly down gradient, the direction of groundwater flow is an indicator of zones at risk from spills and leaks of LNAPLs.

A contaminant plume will eventually reach equilibrium and will not continue to grow in space. This occurs once the rate of natural degradation by dilution, adsorption, dispersion, and chemical and biological degradation equals the input rate.

The length a plume will reach will depend on numerous factors, such as the magnitude and duration of the spill, the oxidation potential of the aquifer to attenuate the spill, and the permeability of the aquifer. Plume lengths are generally less than 100 m and generally do not exceed 300 m, Shih et al. (2004).

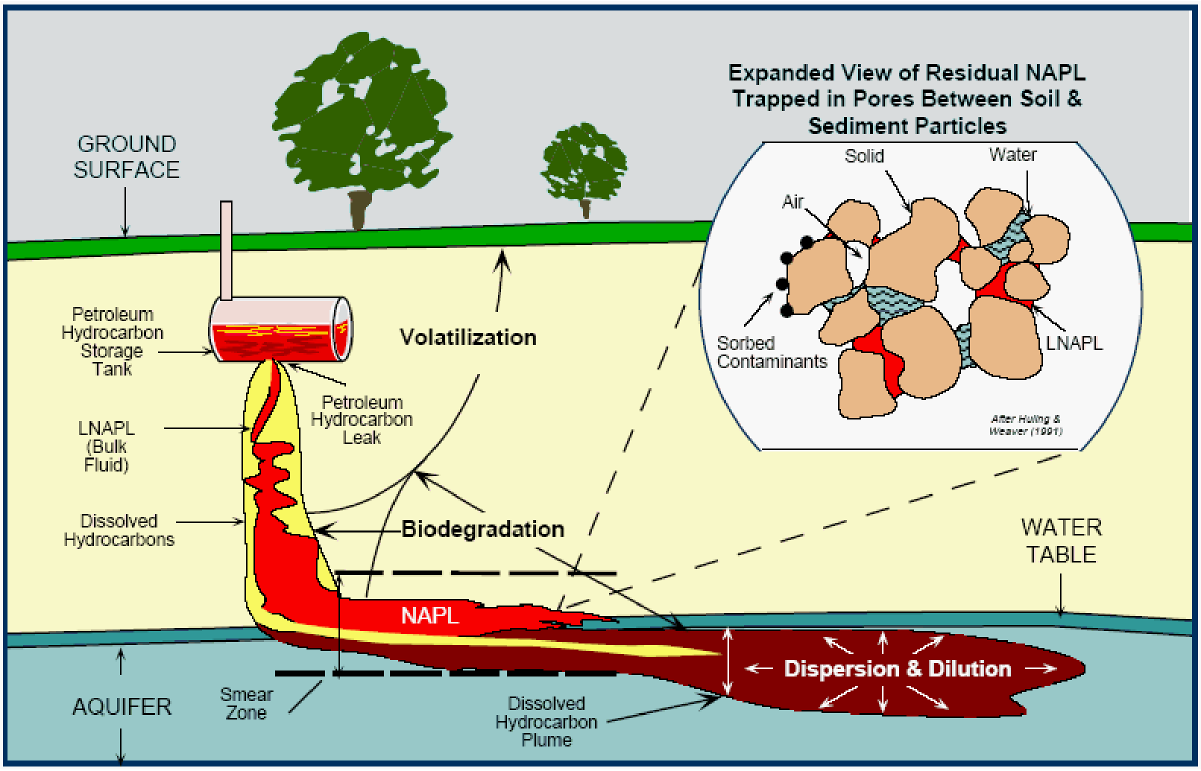


Plate 7-1 Occurrence of LNAPL from a leak

7.2.2 DNAPLS

Dense non-aqueous phase liquids (DNAPLs) are denser than water. They include solvents found in oils and grease.

When a DNAPL spill occurs, it migrates vertically through the unsaturated zone, with some of it retained in the soil. Infiltration of water can subsequently leach this volume, resulting in groundwater contamination along the direction of groundwater flow.

Volatilization of vapours from a DNAPL may also contaminate the ground water and soil.

If the DNAPL spill is large enough, the spill will migrate until it reaches the water table and contaminates the ground water directly. Since its density is greater than water, it continues to migrate downwards until it is intercepted by a low permeability formation where it begins to migrate laterally. Transport of the DNAPL will be largely dependent on the gradient of the stratigraphy. Consequently, flow may be in a different direction than groundwater flow.

Groundwater flowing through this plume will spread contamination down gradient.

DNAPL contamination may exist as four possible phases (Plate 7-2):

- Gaseous phase in the unsaturated zone.
- Trapped in pore spaces in the saturated and unsaturated zone.
- Dissolved phase in groundwater.
- The DNAPL in its original state.

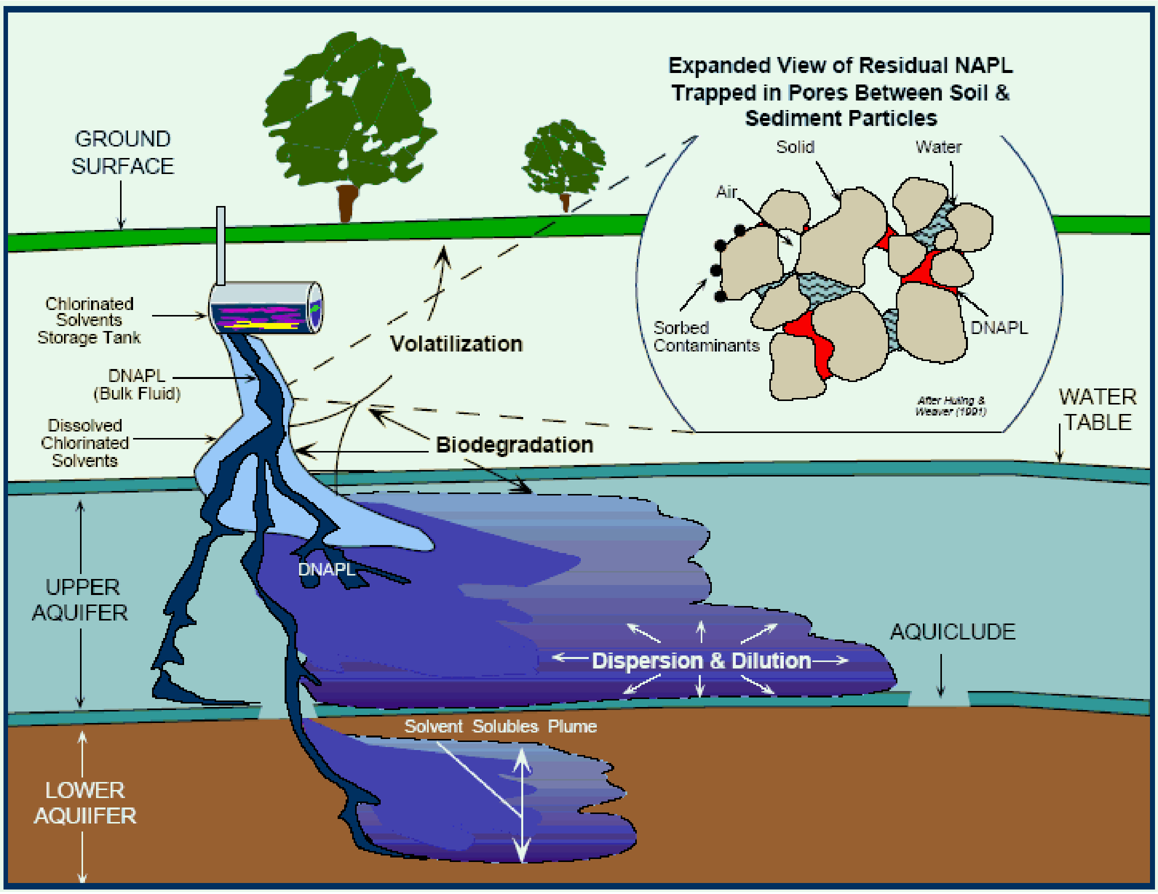


Plate 7-2 Occurrence of DNAPLs from a leak

The fate of any contamination emanating from the filling station is of concern as a potential source of groundwater contamination and seepage to surface water. The extent of any contaminant plume will depend on the volume of the spill and its duration, the rate at which natural attenuation takes place to degrade the spill by natural processes, and aquifer hydraulic properties. The estimated maximum pollution plume is given in Figure 10.

8 GROUNDWATER IMPACT ASSESSMENT

8.1 Impacts of the proposed diesel storage tanks

Two different types of activities are associated with the development: Firstly, the installation and construction must take place (construction phase) before the storage tanks can be put into operation (operational phase).

The proposed activity may detrimentally impact on water resources, including the underlying aquifer and downstream surface waters. These impacts may be associated with leakage from underground pipe fittings and underground storage tanks due to damage or poor maintenance, as well as surface spills and leaks from the forecourt area and the tanker filling area, because of poor operation and management of these areas. Contaminants of concern which would arise from these sources would include petroleum hydrocarbons and dissolved BTEX compounds.

Additional concerns include uncontrolled surface runoff and leakage from the waste storage and handling areas. Contaminants arising from these sources would include microbial indicators, soap, oils, grease, and limited hydrocarbons.

Construction phase

- Sources of water and soil pollution on construction sites include diesel and oil; paint, solvents, cleaners, and other harmful chemicals; and construction debris and dirt.
- Spillages of oil, lubricants and fuel from construction vehicles, plant and machinery has the potential to contaminate the soil and surface and groundwater.
- Spillages and deposition of chemicals onsite can soak into ground water.
- When portions of the site are cleared, combined with the failure to implement erosion control measures effectively, silt-bearing run-off and sedimentation pollution will result.
- Ground disturbing activities such as blasting, and foundation construction can lead to increased erosion.
- Stormwater runoff has the potential to erode the topsoil.
- Soil compaction due to construction activities will reduce aeration, permeability, and water holding capacity of the soils and cause an increase in surface runoff, potentially causing increased sheet or gully erosion.

Operational phase

• Sources of soil and water pollution stem from leakage of the underground storage tanks, pipe works, equipment, and dispensers which are not immediately contained.

• The construction of parking areas and roofing structures will increase the impermeable surface area on the site leading to reduced ground absorption of stormwater and increased surface water runoff. This will further result in an increase in the quantity and velocity of stormwater leaving the site which, in turn, has the potential to transport contaminants away from the site into the natural environments and create soil erosion in vulnerable areas.

8.2 Activity Impact Assessment

Issues and potential impacts were identified that may arise as a result of the proposed development. The classification of each environmental impact was assessed in terms of its:

- duration (time scale)
- extent (spatial scale)
- probability (likelihood of occurring)
- severity (size or degree scale)

The above factors were used to determine the significance of each impact without any mitigation, as well as with mitigation measures. The classification of extent, duration, probability, and severity of impact was undertaken according to the criteria in table 7.

Table 8 Environmental risk and impact assessment criteria

DURATION		Score
Short term	6 months	1
Construction	36 months	2
Life of project		3
Post rehabilitation	Time for re-establishment of natural systems	4
Residual	Beyond the project life	5
EXTENT		
Site specific	Site of the proposed development	1
Local	Surrounding properties	2

District	Municipal district	3
Regional	Region	4
Provincial	Northwest	5
National	Republic of South Africa	6
International	Beyond RSA borders	7

PROBABILITY		
Almost Certain	100% probability of occurrence – is expected to occur	5
Likely	99% - 60% probability of occurrence – will probably occur in most circumstances	4
Possible	59% - 16% chance of occurrence – might occur at some time	3
Unlikely	15% - 6% probability of occurrence – could occur at some time	2
Rare	<5% probability of occurrence – may occur in exceptional circumstances	1
SEVERITY		
Catastrophic (critical)	Total change in area of direct impact, relocation not an option, death, toxic release off-site with detrimental effects, huge financial loss	5
Major (High)	> 50% change in area of direct impact, relocation required and possible, extensive injuries, long term loss in capabilities, off-site release with no detrimental effects, major financial implications	4
Moderate (medium)	20 – 49% change, medium term loss in capabilities, rehabilitation / restoration / treatment required, on-site release with outside assistance, high financial impact	3
Minor	10 – 19% change, short term impact that can be absorbed, on-site release, immediate contained, medium financial implications	2
Insignificant (low)	< 10 % change in the area of impact, low financial implications, localised impact, a small percentage of population	1

Risk is a combination of the probability, or frequency of occurrence of a hazard and the magnitude of the consequence of the occurrence (Nel 2002). Risk estimation (RE) is concerned with the outcome, or consequences of an intention, taking account of the probability of occurrence and can be expressed as P (probability) x S (severity) = RE. Risk evaluation is concerned with determining significance of the estimated risks and also includes the element of risk perception. Risk assessment combines risk estimation and risk evaluation (Nel 2002).

Potential impacts were identified and assessed by considering the criteria as outlined in table 8.

Table 8 Risk estimation

RISK ESTIMATION (Nel 2002)					
	SEVERITY				
PROBABILITY	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Critical (5)
Almost certain (5)	H	H	E	E	E
Likely (4)	M	H	H	E	E
Possible (3)	L	M	H	E	E
Unlikely (2)	L	L	M	H	E
Rare (1)	L	L	M	H	H

E	Extreme risk – immediate action required; detail considerations required in planning by specialists – alternatives to be considered	4
H	High risk – specific management plans required by specialists in planning process to determine if risk can be reduced by design and management and auditing plans in planning process, taking into consideration capacity, capabilities, and desirability – if cannot, alternatives to be considered, senior management responsibility	3
M	Moderate risk – management and monitoring plans required with responsibilities outlined for implementation, middle management responsibility	2
L	Low risk – management as part of routine requirements	1

IMPACT SIGNIFICANCE	
Negligible	The impact is non-existent or insubstantial, is of no or little importance to any stakeholder and can be ignored.
Low	The impact is limited in extent, even if the intensity is major; whatever its probability of occurrence, the impact will not have a significant impact considered in relation to the bigger picture; no major material effect on decisions and is unlikely to require management intervention bearing significant costs.
Moderate	The impact is significant to one or more stakeholders, and its intensity will be medium or high; therefore, the impact may materially affect the decision, and

	management intervention will be required.
High	The impact could render development options controversial or the entire project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor in project decision-making.
Very high	Usually applies to potential benefits arising from projects.

The significance of each impact was determined "without mitigation" and "with mitigation", taking into consideration alternatives, preventative, and mitigation measures.

The groundwater risk and impact assessment are provided in table 9.

Table 9 Impacts on groundwater.

Impact	E	D	S	P	RE	Without mitigation	Mitigation
Impact on water balance and water levels from increased abstraction	1	1	1	1	1	The impact is negligible as no abstraction may occur	No mitigation possible
Contamination by wastewater during construction	2	1	2	2	2	Containment of dirty water during construction may infiltrate into the ground. This water could include salts and oils, as well as bacteriological contaminants	Containment of dirty water
Accidental spillage	1	2	3	2	3	On hard surfaces like the forecourt, the product can be covered and adsorbed with biodegradable absorbent materials. Spills on soils would require determining the vertical and lateral extent of contamination and an assessment of the risk of migration to determine if remedial action is required	Containment of spills
Overfills	1	2	3	3	3	On hard surfaces like the forecourt, the product can be covered and adsorbed with biodegradable absorbent materials. Spills on soils would require determining the vertical and lateral extent of contamination and an assessment of the risk of migration to determine if remedial action is required	Secondary containment around filler points and on top of tanks

Leaking tanks	2	3	3	3	3	Leaking USTs allow the LNAPL quick access to the water table, bypassing the bulk of the upper soil zone. Free product could accumulate at the water table and contribute dissolved BTEX constituents to groundwater flow through the site	Reconciliation of delivery and sales, monitoring wells for early detection, in line leak detection
Migration of pollution plume to surface water bodies and groundwater users	1	3	1	1	1	If a dissolved phase of LNAPL or DNAPL occurs, the plume could migrate north-westwards to a drainage line where the water table is shallow, however, this is 780m away and would take more than 20years with natural attenuation.	Rapid assessment of leaks and implementation of pump and treat or oxidation remediation technologies.

9 MONITORING AND MANAGEMENT

The installation of USTs is covered by SANS 10089-3:2010.

Spills and leaks may occur, and minimising impacts requires rapid detection and response. To minimise the risk of a spill or leak the following are required:

- Spill and leak prevention.
- Spill and leak response procedures.
- Spill and leak monitoring.

9.1 Spill and leak prevention

Spill and leak prevention are part of the environmental plan and employee training.

The following minimum precautionary measures are recommended:

- Sealing of the forecourt area and other areas where fuel products are handled to prevent infiltration of petroleum products into the soil/rock underlying the site;
- Storm water draining from the surfaced areas should be collected in a sealed sump to be treated and/or removed;
- Preventative measures should be installed to prevent the storm water or other liquids draining into the natural soil.

Due to the relatively shallow groundwater level, the underlying aquifer is vulnerable to spillages.

The following will be recommended:

- Subsurface fuel tanks should be placed in concrete or PVC encasements with a sump system to prevent spilled fuel from entering the bedrock or aquifer.
- Fuel lines and dispensers should be rendered leak-proof and are recommended to be placed in encasements.
- Leak detectors are a preferred design alternative. In best practice tank and infrastructure design, leak detectors are installed which immediately switch off the submersible pump contained within the tank should a leak be detected.
- Overfill protection in the tank filling pipe work to prevent tank overfills during filling operations, preventing surface spillage.
- Above ground tanks require a berm and collection system

9.2 Spill and Leak Response

Spill response includes procedure to limit the spill, contain the spill, remove as much as possible of the spilled product, and a clean-up and soil and groundwater rehabilitation. Containing the spill localises the problem and minimises the extent of pollution. The clean-up process is determined by the volume of spill, whether it occurs on surface over paving, over soil, or is a leak from USTs.

Minor spills of less than 200 litres can be soaked up with fibres and a spill soaked into soil can be ploughed up to allow aeration to remediate the pollution.

Major spills can be contained by stopping the flow of product through control valves, turning off pumps, containing the spill with absorbing fibres, sandbags, sand, or soil, preventing a spill from entering drains and storm water systems and creating a barrier to migration to water courses and flowing over permeable surfaces. Spills over soil require ploughing up of soil and the application of oxidising chemicals to increase oxidation.

9.3 Groundwater Monitoring

To detect any changes in the aquifer system, as well as potential pollution derived directly or indirectly from the proposed development, monitoring of water levels and flow rates, water quality and trends, is imperative.

Early detection and identification of leaks requires a groundwater monitoring plan. Monitoring boreholes should be located up and down gradient of the USTs, which means to the NW and SE of the tanks. They should be constructed with continuous screens above and below the water table to accommodate rising and falling water table and capable of sampling an LNAPL floating on the water table, and dissolved phase constituents below the water table. Monitoring wells must be of uPVC or HDPE material and have an internal diameter of at least 50mm. It is recommended that a minimum of one up gradient and two down gradient wells be installed. The depth of the well must be at least 2m below the depth of the storage tank, or to the water level. Wellheads on boreholes down gradient of the proposed facility must be constructed to prevent any ingress of surface water either from a spill or flooding.

Early detection monitoring wells are to be sunk in the sand back fill adjacent to tanks for the monitoring of groundwater and identification of possible leaking tanks. In the past, oil companies did not install monitoring wells, which resulted in significant delays in detecting any subsurface product losses, with an associated high level of environmental risk. These can be established before back filling takes place, using high density polyethylene slotted / perforated pipes of 160 mm outside diameter, wrapped in a porous geotextile, or ABS (acrylonitrile-butadeine-styrene) single-walled wedge-slot tubular screens installed in each corner of the excavation to act as future observation wells. The bottom ends need to be plugged and the top ends finished off with a suitable plumber plug. The wells need to extend down to 500 mm below the floor of the excavation.

A proper groundwater quality monitoring program must be implemented as soon as possible, where initial sampling and analysis should allow for all major chemical, physical and bacteriological constituents as per (SANS 241). Follow-up sampling could monitor elements in excess only, as well as for traces of hydrocarbon contamination.

Teflon bailers can be used to sample the surface and just below surface of the water table. External user boreholes down gradient of the USTs should also be sampled. Accredited laboratories have set standards for sample preservation, holding times and sampling bottles and these specifications should be followed.

The monitoring programme should be audited for compliance to the stated objectives and adapted when and where required.

The network should be maintained and protected from vandalism and damage by vehicles. Table 10 lists a proposed monitoring schedule.

Table 10: Monitoring schedule recommended.

	Weekly	Monthly	Quarterly	Annually
Monitoring borehole		Water level Presence of LNAPL on surface of water table	pH Electrical conductivity Faecal coliforms Nitrates Chemical oxygen demand	pH Electrical conductivity Faecal coliforms Nitrates Chemical oxygen demand Ca, Mg, Na, K, T-Alk, Cl, SO_4, F, Al, Fe, Mn TPH/BTEX

10 CONCLUSION AND RECOMMENDATIONS

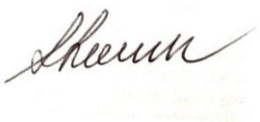
From the evaluation, the following conclusions are made:

- Currently no groundwater use occurs on the development site, the primary water source will be municipal water;
- The onsite underlying geology consists of Hout River Gneiss;
- The underlying soils are permeable with indication of seasonal seepage occurring;
- Groundwater occurs mainly in weathered and fractured aquifers, with > 5.0 l/s yields;
- Regional groundwater flow is expected to mimic a subdued form of the surface topography and the flow direction is thought to be in a north western direction towards the Sand River, the property is in the A71A quaternary catchment area;
- From the National Ground Water Archive (NGA) and GRIP data the boreholes in the area are high yielding with moderately to shallow water levels;
- From the Hydrocensus data, abstractions are small scale with moderate water levels;

- A Water sample of boreholes BH1 was taken and submitted to a SANAS accredited laboratory to test the water chemistry, BTEX and TPH;
- The water sample resulted in water Chemistry quality of **Class I**, Good quality with slightly elevated Nitrate, Hardness, TDS and conductivity;
- BTEX and TPH tests indicated no pollution thereof in the area and will serve as background data for future studies and monitoring;
- The property is connected to Municipal sewerage
- The aquifers in the area will be at a medium to high risk of pollution from spills at the proposed filling station development;
- Management and monitoring measures as described in paragraph 9 will need to be implemented to reduce the risk;

The following recommendations are made:

- That a monitor borehole is drilled directly downstream of the proposed diesel storage tanks;
- That the monitor borehole be monitored according to the monitoring schedule given in table 10;
- That the mitigation measures as specified in table 9 be implemented;
- That a management and monitoring programme be implemented (see section 9);



SJ Koekemoer BSc (Hons)
Qualified Hydrogeologist

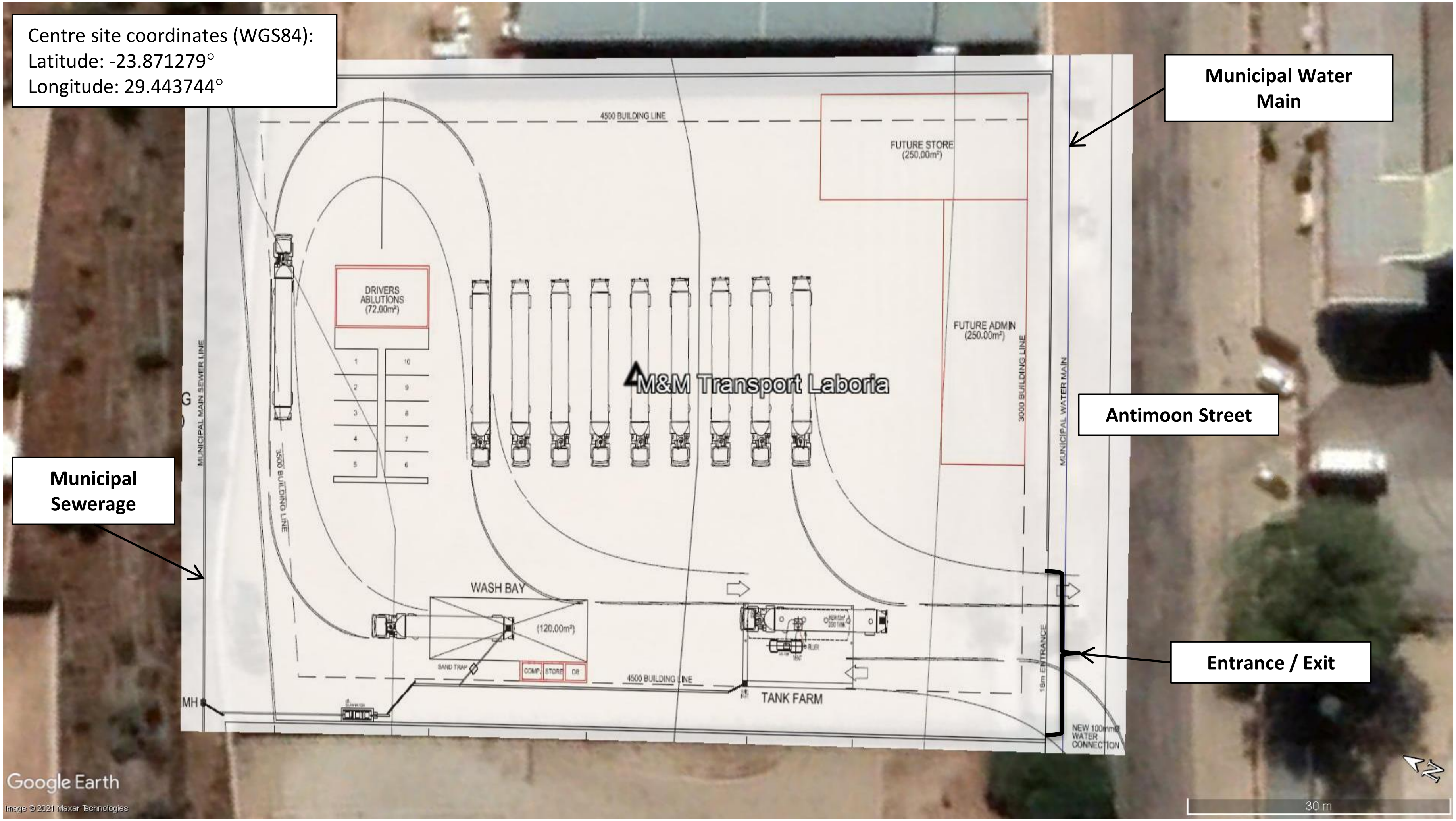
C J Haupt BSc (Hons) Pr.Sci.Nat.
Principal Hydrogeologist
SACNASP registration no. 40003194

Appendix A (Figures)

Project Description: M&M Transport Diesel Depot
Investigation Type: Hydrogeological Investigation
Figure 1: Locality Map

WSM LESHIKA CONSULTING (PTY) LTD

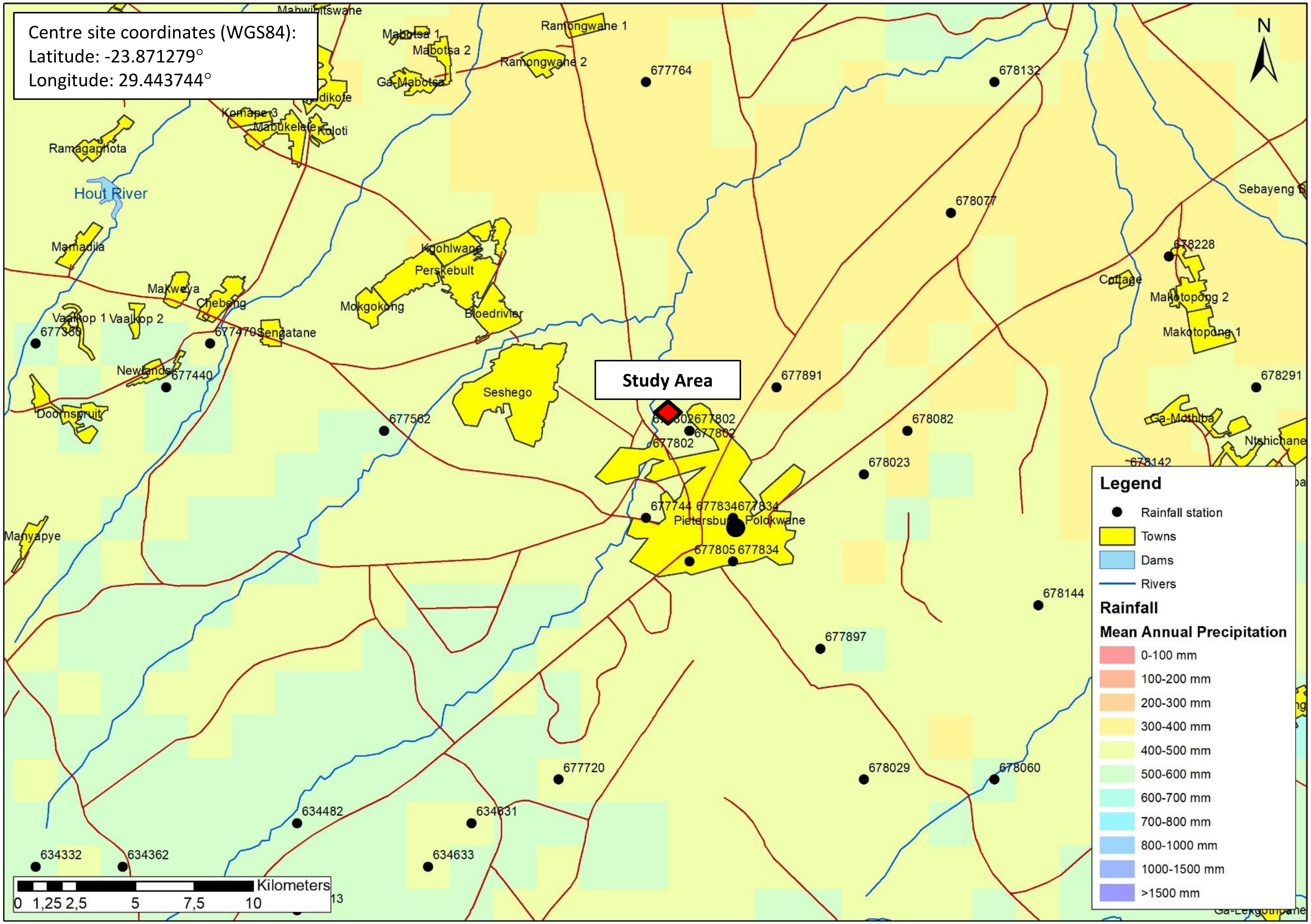
Project no: WH21030



Project Description: M&M Transport Diesel Depot
Investigation Type: Hydrogeological Investigation
Figure 2: Layout Map

WSM LESHIKA CONSULTING (PTY) LTD

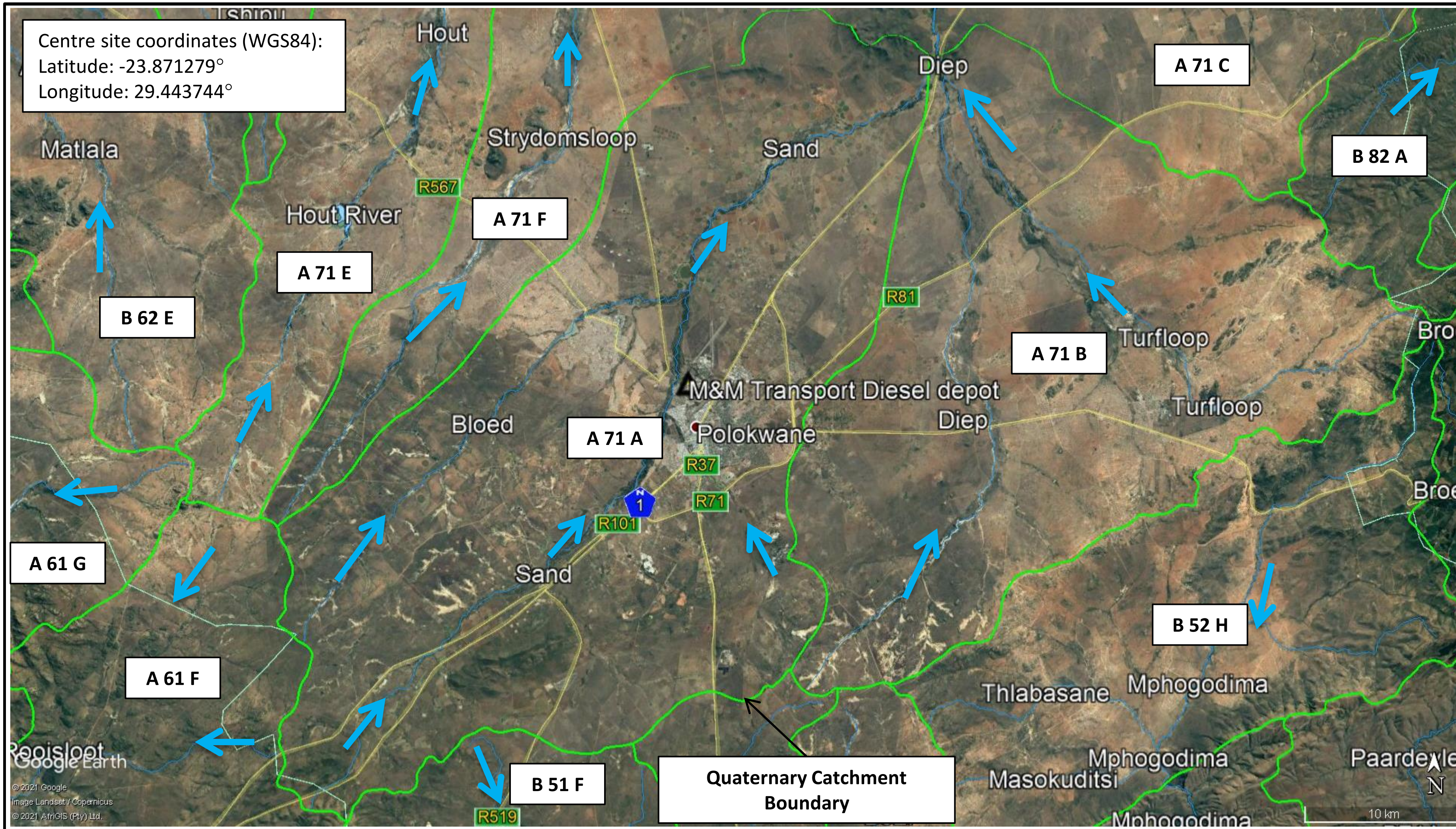
Project no: WH21030



Project Description: M&M Transport Diesel Depot
Investigation Type: Hydrogeological Investigation
Figure 3: Rainfall Map

WSM LESHIKA CONSULTING (PTY) LTD

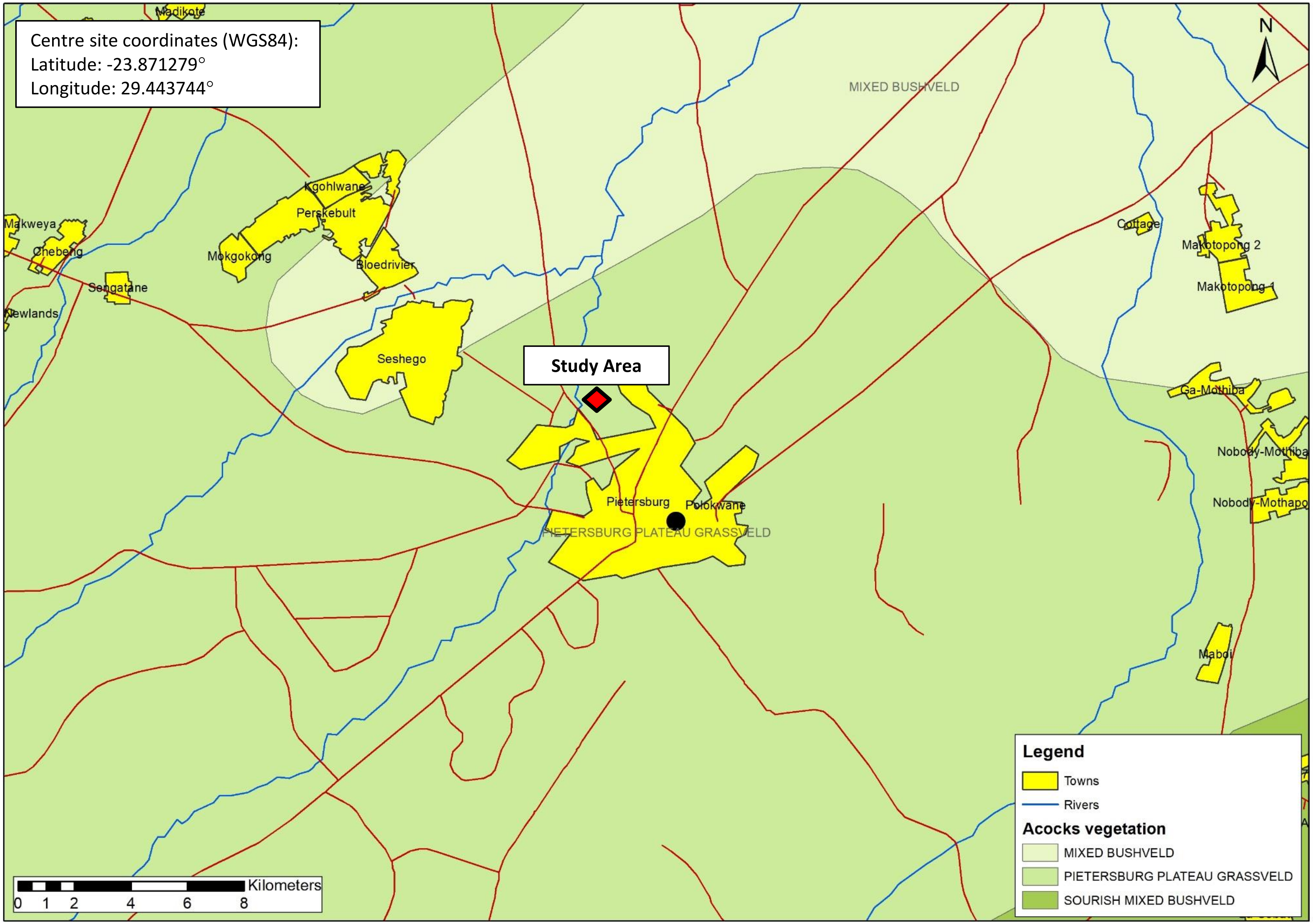
Project no: WH21030



Project Description: M&M Transport Diesel Depot
Investigation Type: Hydrogeological Investigation
Figure 4: Quaternary Catchment Map

WSM LESHIKA CONSULTING (PTY) LTD

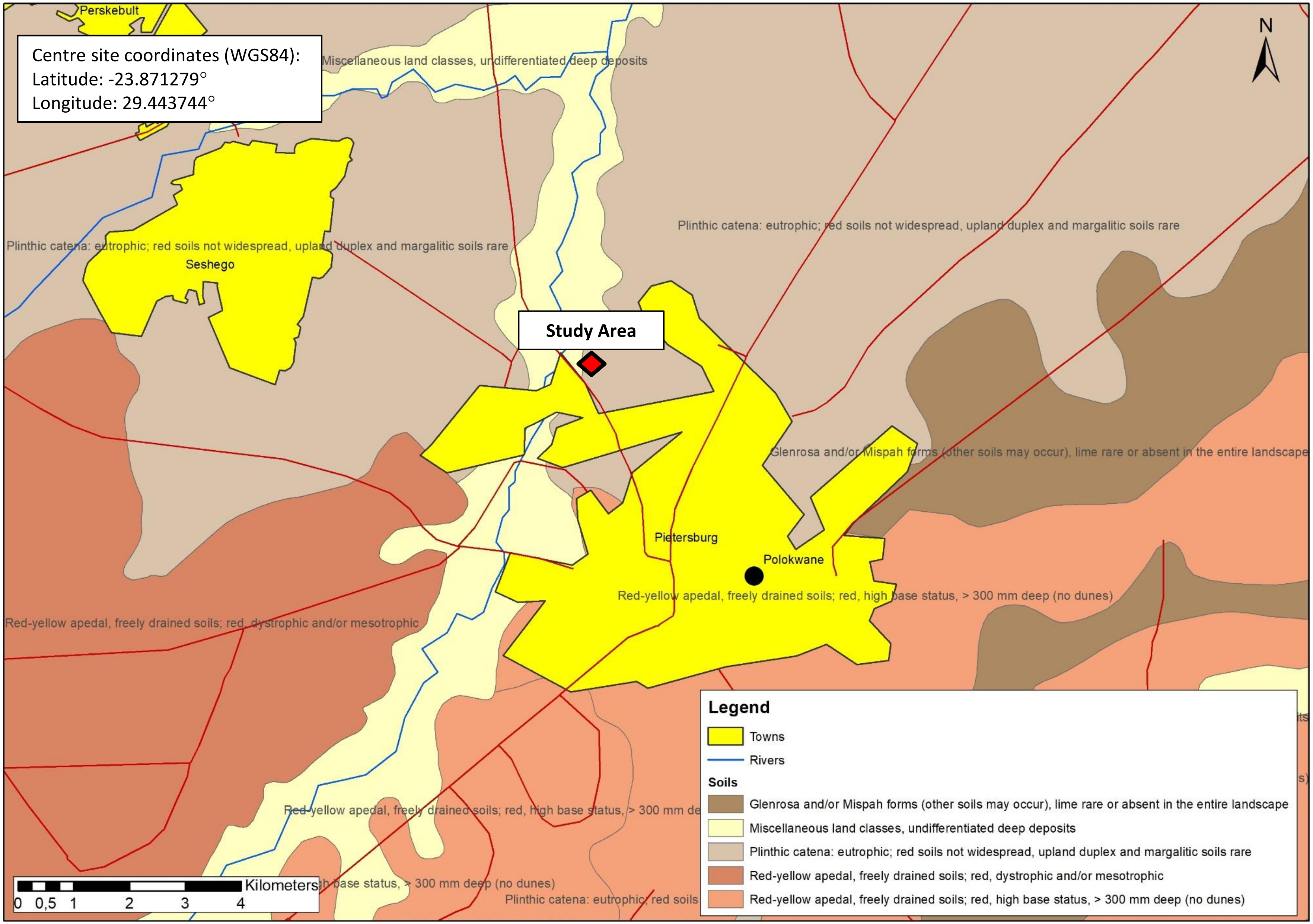
Project no: WH21030



Project Description: M&M Transport Diesel Depot
Investigation Type: Hydrogeological Investigation
Figure 5: Vegetation Map

WSM LESHIKA CONSULTING (PTY) LTD

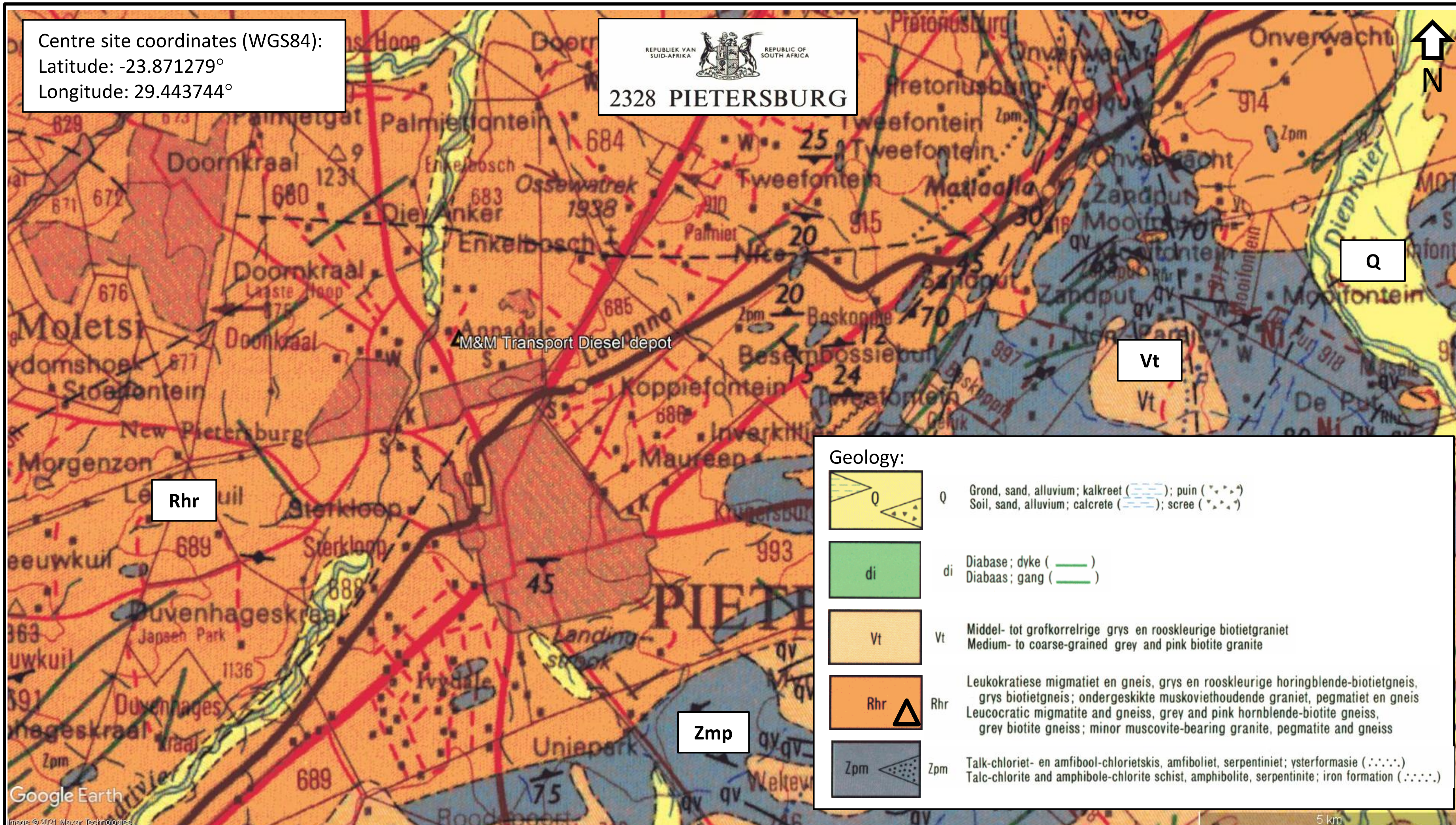
Project no: WH21030



Project Description: M&M Transport Diesel Depot
Investigation Type: Hydrogeological Investigation
Figure 6: Soils Map

WSM LESHIKA CONSULTING (PTY) LTD

Project no: WH21030



Project Description: M&M Transport Diesel Depot
Investigation Type: Hydrogeological Investigation
Figure 7: Regional Geological Sheet – 1:250 000-scale 2328 Pietersburg

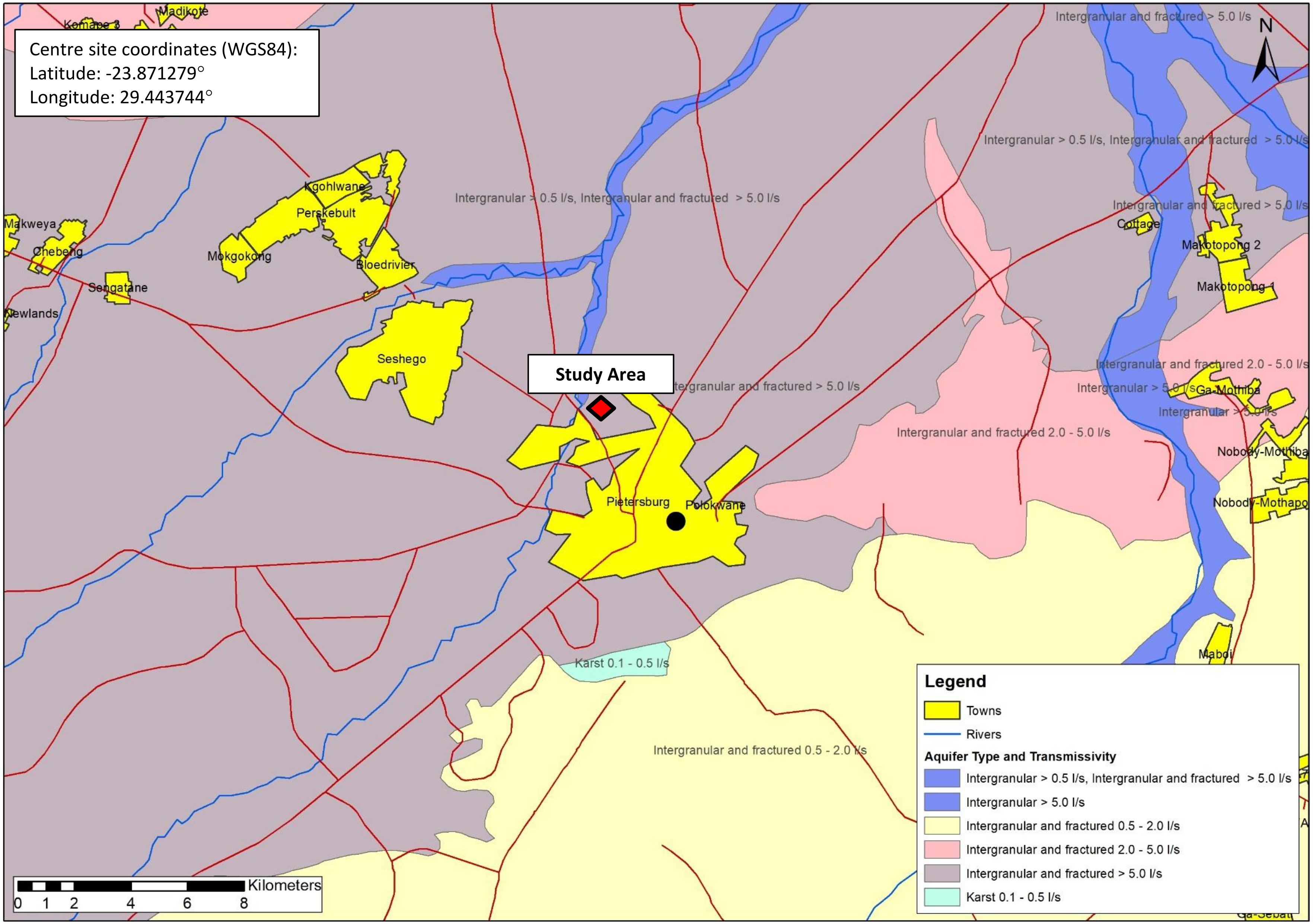
WSM LESHIKA CONSULTING (PTY) LTD

Project no: WH21030

Project Description: M&M Transport Diesel depot
Investigation Type: Hydrogeological Investigation
Figure 8: Hydrocensus Map

WSM LESHIKA CONSULTING (PTY) LTD

Project no: WH21030



Project Description: M&M Transport Diesel Depot
Investigation Type: Hydrogeological Investigation
Figure 9: Aquifer Map

WSM LESHIKA CONSULTING (PTY) LTD

Project no: WH21030

Project Description: M&M Transport Diesel depot
Investigation Type: Hydrogeological Investigation
Figure 10: Estimated maximum pollution plume emanating from a spill

WSM LESHIKA CONSULTING (PTY) LTD

Project no: WH21030

APPENDIX B

(WATER QUALITY RESULTS)

CAPRICORN VETERINARY LABORATORIES

ANALYTICAL & DIAGNOSTIC LABORATORY SERVICES

215 Marshall Street, Flora Park, Polokwane, South Africa
P.O. Box 115 Bendor Park 0713
Tel: +27(15) 297-6666
E-mail: info@caprivet.co.za

LABORATORY TEST REPORT

WATER CHEMISTRY:

Your reference: WH210 M & M Transport
Our reference: 21/09/4026
Enquiries: 015 297-6666
Date report issued: 2021/09/30

Sender/ Client:	WSM Leshika	**Owner:**	Not specified
Person sent:	Shawn Koekemoer	**Sample origin:**	On site – Polokwane Laboria
Postal:	Postnet Suite 8 P/Bag X9676 Polokwane 0700	**Postal:**	Not specified Not specified Not specified Not specified
Tel:	082 514 9947	**Tel:**	Not specified
E-mail:	skoekemoer@wsmleshika.co.za	**E-mail:**	Not specified

Water

1. Samples received:
1 x ground water sample(s) as indicated in Table 1.

1.1 Date sample(s) received: 2021/09/22
1.2 Time sample(s) received: 10h23
1.3 Date test(s) started: 2021/09/23
1.4 Date report completed: 2021/09/30

2. Required test(s):
2.1 Water chemistry

3. Test method
The sample(s) were tested in accordance with:

3.1 Refer to Table 1

4. Sample and condition/…

4. Sample and condition :

4.1 Date of sampling:	2021/09/22
4.2 Date sample submitted:	2021/09/22
4.3 Temp. upon sample reception:	21.1℃
4.4 Sample defects noted:	None

5. Sub contractor:

5.1 None

6. Results:

6.1 Refer to table 1.

Table 1/…

Table 1:
Refer to 2.1

Determinand	Test Method Reference	Unit	1-21/4026 BH 1 WH210 Laboria M&M Transport 22/09/2021
Physical and aggregate properties			
pH @ 25℃	CH-METH-001	pH units	7.2
Conductivity @25℃	CH-METH-002	mS/m	88.4
*Total dissolved solids (calculated)	CH-METH-038	mg/l	574
Alkalinity			
*Bicarbonate alkalinity as $CaCO_3$	CH-METH-054	mg/l	225.8
*Carbonate alkalinity as $CaCO_3$		mg/l	0.0
Hardness:			
*Total hardness as $CaCO_3$	CH-METH-039	mg/l	284.74
*Ca hardness as $CaCO_3$		mg/l	125.25
*Mg hardness as $CaCO_3$		mg/l	159.49
Metals			
Aluminium as Al	CH-METH-020	mg/l	0.01
Arsenic as As	CH-METH-020	mg/l	<0.03
Calcium as Ca	CH-METH-020	mg/l	50.10
Copper as Cu	CH-METH-020	mg/l	0.01
Iron as Fe	CH-METH-020	mg/l	<0.01
Magnesium as Mg	CH-METH-020	mg/l	38.90
Manganese as Mn	CH-METH-020	mg/l	<0.01
Potassium as K	CH-METH-020	mg/l	5.90
Sodium as Na	CH-METH-020	mg/l	72.17
Inorganic non-metallic constituents			
Chloride as Cl	CH-METH-050	mg/l	98.0
Fluoride as F	CH-METH-013	mg/l	0.45
Nitrogen			
*Ammonium as NH_4-N	CH-METH-031	mg/l	<0.20
Nitrate as NO_3-N	CH-METH-050	mg/l	7.66
*Nitrite as NO_2-N	CH-METH-011	mg/l	<0.01
Phosphorus			
Ortophosphate as PO_4-P	CH-METH-032	mg/l	<0.05
Sulphur			
Sulphate as SO_4	CH-METH-050	mg/l	57.31
Silica			
*Silica as Si	CH-METH-020	mg/l	35.97

Key:
* - Not a SANAS accredited method

7. Comments/…

<u>Disclaimer:</u> Comments and interpretations expressed herein are not within the scope of SANAS accreditation.

7. Comments:

7.1 None

8. Interpretations:

8.1 None

(Technical Signatory)

(END OF REPORT)

Test Report - BTEX analysis

Capricorn Veterinary Laboratories CC
P.O Box 115
Bendor Park
0713

Samples Received: 2021-09-23
Sampled by: Unknown
Report # : F22-02747
Order #: None
Acc # : C108
Testing Date GC: 2021-09-30

Telephone: 015 297 6666

E-mail: milan@caprivet.co.za

Sample condition: Average
Sub-contractor: None

Sample name: 21/09/4027 - 1

Method of test: BTEX analysis in water and waste water

Compound	Concentration (ppb)
MTBE	<100
Benzene	<10
Toluene	<10
Ethylbenzene	<10
m+p-Xylene	<10
o-xylene	<10

Date: 2021-10-01

Labserve Analytical Services
Nebo Park, Suikerriet Str, Nelspruit
Telephone : +27 (13) 752 4745
Facsimile : +27 (13) 752 4617
P.O. Box 1920, Nelspruit, 1200
E-mail: info@labserve.net
www.labserve.net

Test Report - TPH Analysis

Capricorn Veterinary Laboratories CC
P.O Box 115
Bendor Park
0713

Telephone: 015 297 6666

E-mail: milan@caprivet.co.za

Samples Received: 2021-09-23
Sampled by: Unknown
Report # : F22-02747
Order #: None
Acc # : C108
GC Testing Date: 2021-09-30

Sample condition: Average
Sub-contractor: None

Sample name: 21/09/4027 - 1

Method of test: TPH GC/MS (Hexane extraction - Aliphatic)*

Compound	Concentration (ppb)
C8	<2.5
C9	<2.5
C10	<2.5
C11	<2.5
C12	<2.5
C13	<2.5
C14	<2.5
C15	<2.5
C16	<2.5
C17	<2.5
C18	<2.5
C19	<2.5
C20	<2.5
C21	<2.5
C22	<2.5
C23	<2.5
C24	<2.5

Compound	Concentration (ppb)
C25	<2.5
C26	<2.5
C27	<2.5
C28	<2.5
C29	<2.5
C30	<2.5
C31	<2.5
C32	<2.5
C33	<2.5
C34	<2.5
C35	<2.5
C36	<2.5
C37	<2.5
C38	<2.5
C39	<2.5
C40	<2.5

TOG (mg/L)**	<1

*C*x* refers to the liniear hydrocarbon of chain length *x.*
** Gravimetric (Also refered to as HEM)

Date: 2021-10-01