Geohydrological Assessment for the proposed development of the Richards Bay Combined Cycle Power Plant (CCPP) and associated infrastructure on a site near Richards Bay, KwaZulu-Natal Province

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Declaration

I, the undersigned, declare that I am an independent Consultant with no interest in this application. I have over 20 years of fieldwork and project management experience in the research, mining, oil and gas sectors, firstly as a geologist and following completion of my Masters degree in Geohydrology at the University of the Free State. I am registered to SACNASP (Water Resources Science). I have extensive experience in developing geological and hydrogeological conceptual models for groundwater modeling. I managed various hydrogeological investigations for contaminated sites and as part of environmental impact assessments (EIA), Environmental management plan (EMP), water use licence application (WULA) and waste management licence application (WMLA), mining water management studies.

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I am appointed by AFZELIA (Pty) Ltd (on the behalf of the department of ESKOM).

Executive Summary

Geo Hydraulic and Environmental Technology (Pty) Ltd (hereafter referred to as "GET") was appointed by Afzelia (Pty) Ltd to perform a geohydrological specialist assessment as part of the Environmental Impact Assessment (EIA) for the proposed Combined Cycle Power Plant (CCPP) near Richards Bay on Erf 2/11376 and Erf 4/11376 (hereafter referred to as "site"), in KwaZulu-Natal Province.

The focus of the investigation is to review and assess the baseline groundwater conditions at the proposed site and to identify potential sensitive environments and receptors that may be impacted by the CCPP. Types of potential impacts and mitigation measures as part of the EIA process will also form part of the investigation.

The site is underlain by quaternary grey yellowish distributed sand, sandy clay and clayey sand which overlays the mudstone, shale, sandstone, lignite and sand of the Port Durnford formation. Groundwater occurs within the shallow inter-granular primary aquifer in the unconsolidated materials deposited during the Tertiary and Quaternary periods. Field geohydrological data indicated that there are two types of aquifers underlying the site including a shallow primary aquifer and a deep fractured aquifer. The current site groundwater level within the shallow primary aquifer varies from 0.64 to 3.89 mbgl. It is anticipated that a fractured aquifer undelaying the site is likely to be located at more than 11 mbgl.

Available data reviewed indicated no abstraction boreholes in the vicinity of the site. Surface water bodies are used as a source of water supply to industries and mines.

The following potential impacts were identified within the site:

- Groundwater flow direction will be impacted throughout the site area only for the duration of the construction phase, as groundwater will recover its initial conditions after completion of construction.
- Groundwater level will be lowered during the construction phase, due to dewatering to facilitate erection of building foundation, static water level being between 0.64 to 3.89 mbgl.
- During the construction phase, a potential impact exists on groundwater and surface water bodies including the Nseleni River, Nsezi dam, Voor River and Bhizolo Stream and an unnamed dam (receptors), as a result of on-site accidental fuel spills and leaks (sources) from construction vehicles and/or fuel storage areas. Fuel spills can either migrate off-site

to surrounding surface water bodies by means of rain surface runoff or seep into the groundwater by means of rain water seepage (pathways).

- During the construction phase, a potential impact exists for identified receptors as a result of leachate from construction waste disposal areas (sources) and infiltration through soil (pathway) of dirty water from ablution facilities (sources).
- During the operation phase, a potential impact exists on groundwater and surface water bodies including the Nseleni River, Nsezi dam, Voor River, Bhizolo Stream and an unnamed dam (receptors) due to possible leakage of diesel and/or chemicals from storage facilities and/or pipelines and from emergency backup generators leaks (sources). With rain water seepage, hydrocarbon products (diesel) can migrate through unconsolidated formations and the reach groundwater table or migrate off-site to surface water bodies by means of rain water runoff (pathways).
- During the operation phase, a potential impact exists on identified receptors due to waste water discharges from the waste water treatment plant and pond (sources) by means of water seepage and/or rain surface runoff (pathways).
- A potential cumulative impact on groundwater quality can be expected during operation phase as a result of industrial activities from Mondi Plant located adjacent to the site.

A groundwater monitoring plan is required to monitor the proposed CCPP activities from negatively impacting the groundwater quality and quantity. As part of the monitoring plan to be included in the environmental management plan the following actions are required:

- Site groundwater monitoring network will consist of background monitoring borehole (BH_M2) and two impact monitoring boreholes as early warning of groundwater contamination (BH_M1 and BH_M3).
- A second groundwater sampling run and groundwater levels measurements during the dry season needs to be performed by a geohydrologist before the construction phase for a baseline quality data characterisation.
- During the operation phase, groundwater level and quality needs to be monitored weekly. This will assist in detecting early contaminated groundwater migration to off-site receptors and in initiating a prompt remediation process.
- Because of groundwater and surface interaction within the study area, it is suggested that surface water monitoring of the Nsezi dam, Nseleni River, Voor River and Bhizolo stream in the vicinity of the CCPP is also undertaken to assess any impact during the construction phase and when the CCPP is operational.
- The dirty water retention dam needs to be lined to prevent any seepage of waste water.

Based on the desktop and site geohydrological impact assessment, the following can be concluded:

- The site is essentially underlain by quaternary yellowish distributed sand which overlays the granite, conglomerate, sandstone as well as lignite and sand of the Port Durnford formation.
- A shallow groundwater table occurs within the inter-granular primary aquifer in unconsolidated materials deposited during the Tertiary and Quaternary periods. The current site groundwater level within the shallow primary aquifer varies from 0.64 to 3.89 mbgl. The shallow aquifer transmissivity (T) value is approximatively 1.97m2/d. It is anticipated that a deep fractured aquifer exists below 11 mbgl.
- The site has two hydraulic gradients, one slopping towards west and the other towards the east. Therefore, the groundwater flows both easterly and westerly with a possible divide in the central area.
- the chemical constituents from the three boreholes are compliant to SANS 241:2015 guidelines except for Total Coliforms, iron, E-coli, Colour, Standard plate count and turbidity. The presence of TPH in one new borehole is likely to originate from drilling tools used. This needs to be confirmed through a second groundwater sampling run.
- Without the implementation of any mitigation measures the significance of potential impacts to groundwater and surface water bodies at the site is high. The implementation of the mitigation measures reduces the significance rating to medium to low.

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1 Introduction and Background

Geo Hydraulic and Environmental Technology (Pty) Ltd (hereafter referred to as "GET") was appointed by Afzelia (Pty) Ltd on behalf of Savannah Environmental (Pty) Ltd to perform a geohydrological specialist assessment at the project site 7 "Erf 2/11376 and Erf 4/11376" (hereafter referred to as "the site") as a component of the Environmental Impact Assessment (EIA). The site is located approximately 5 km from Richards Bay Central, in the City of uMhlathuze Local Municipality, northern Kwazulu Natal.

2 Objective and Scope of Work

2.1 Objectives

The objective of the geohydrological assessment is to determine, through site investigations and the use of existing information, the significance of potential impacts of the proposed CCPP, on the receiving groundwater environment and to recommend relevant practical mitigation measures.

2.2 Scope of Work

The scope of work applicable to the geohydrological assessment includes the following:

- Desktop review and description of baseline geological and hydrogeological characteristics of the site.
- Identify existing registered boreholes within 1 km radius of the site, using both Groundwater Resource Information Project (GRIP) data and National Groundwater Archive (NGA) data.
- Site investigation consisting of Hydrocensus survey, installation of monitoring boreholes, slug test and groundwater sampling.
- Assessment of the baseline groundwater quality using the Water Management System (WMS) which contains hydrochemical data.
- Identifying data gaps related to groundwater condition in the vicinity of the site.
- Identifying the potential impacts the CCPP would have on the receiving groundwater environment based upon the findings of the investigation.
- Determine the significance of the potential impacts and propose mitigation measures, monitoring plan and recommendations.
- Compile a geohydrological assessment report incorporating all of the above.

2.3 Available data Sources

The following data sources were reviewed for the study:

- 1:25000 Hydrogeological map, 2830 Dundee from the Department of Water and Sanitation;
- 1:250 000 Geological series 2830 Dundee from the Department of Mineral and Energy Affairs;
- 1:250 000 Geological series 28(1/2)30 St Lucia from Department of Mineral and Energy Affairs;
- The National Groundwater Archive (NGA) which listed records of registered boreholes;
- The Water Management System (WMS) which contains hydrochemical data;
- Water Authorisation Registration Management System (WARMS) for registered and licensed groundwater use;
- CSIR (2006), A Conservation Vision for the Freshwater Biodiversity of the Olifants, Inkomati and Usutu-Mhlathuze Water Management Areas, Directorate: Resource Directed Measures, DWA;
- Golder Associates (2014), Zulti South-Phase I Groundwater report, Hydrocensus and information review;
- Germishuyse T, (1999), A Geohydrological Study of the Richards Bay Area, Msc Thesis.
- SRK (2008) Groundwater Baseline and Impact Assessment for the Establishment of Servitudes for the Inhlansi Project, Richards Bay; and
- All information made available by the Client.

2.4 Legal Framework

Surface water and groundwater management is regulated by the following legal framework:

- National Water Act (No 36 of 1998);
- National Environmental Management Act, NEMA, Act 107 of 1998, under Regulations R324 to 327, of 07 April 2014; and
- Mhlathuze Water Service Bylaw, Section 64.

3 Project Description

3.1 Location of the Proposed Site

The site is situated within the quaternary catchments W12F, in the City of uMhlathuze, northern KwaZulu-Natal Province. The site is located at the approximate geographical coordinates of 28º46’04.54”S, 31º 58’54.74”E. The site location is indicated in *Figure 3-1* and *Figure 3-2*.

3.1.1 Surrounding Land Use

Table 3-1: Surrounding land use

Preferred project site		
Direction from Site	Land Use	Other Information
North	Farming land	Railway-line, Natural forest
East	Industrial	Railway-line and Mondi Plant
South	Vacant land	Railway-line, Natural forest and vacant land
West	Farming land	Natural forest, Railway-line and Nsezi Dam

3.2 Proposed Project Infrastructure Components

The project infrastructure components for the proposed the CCPP power plant consist of the following (information provided by Eskom):

- Gas turbines for the generation of electricity through the use of natural gas or diesel (back-up resource).
- Heat recovery steam generators (HRSG) to capture heat from high temperature exhaust gases to produce high temperature and high-pressure dry steam to be utilised in the steam turbines.
- Steam turbines for the generation of additional electricity through the use of dry steam generated by the HRSG.
- Bypass stacks associated with each gas turbine.
- Dirty Water Retention Dams.
- Exhaust stacks for the discharge of combustion gases into the atmosphere.
- A water treatment plant for the treatment of potable water and the production of demineralised water (for steam generation).

- Water pipelines and water tanks to transport and store water of both industrial quality and potable quality (to be supplied by the Local Municipality).
- Dry-cooled system consisting of air-cooled condenser fans situated in fan banks.
- Closed Fin-fan coolers to cool lubrication oil for the gas and steam turbines.
- A gas pipeline and a gas pipeline supply conditioning process facility for the conditioning and measuring of the natural gas prior to being supplied to the gas turbines. It must be noted however that the environmental permitting processes for the gas pipeline construction and operation will be undertaken under a separate EIA Process
- Diesel off-loading facility and storage tanks.
- Ancillary infrastructure including access roads, warehousing, buildings, access control facilities and workshop area, storage facilities, emergency back-up generators, firefighting systems, laydown areas and 132kV and 400kV switchyards.
- A power line to connect the Richards Bay CCPP to the national grid for the evacuation of the generated electricity. It must be noted however that the due environmental permitting processes for the development of the power line component are being undertaken under a separate EIA Process.

3.3 Proposed Project Operation

Natural gas will be used primarily to operate the CCPP to generate electricity of 3 000 MW, with diesel as backup. The following steps are designed for the CCPP operation as per Eskom's data:

- A Gas turbine burns fuel together with compressed air to produce very high temperature combustion gas;
- The hot combustion gas produced causes the gas turbine blades to spin;
- The spinning energy is converted into electricity by means of a connected generator;
- The exhaust waste heat from the gas turbine is captured by the HRSG and used to generate high temperature and pressure steam; and
- The steam turbine uses the hot steam to generate additional electricity.

It is anticipated that the natural gas will be supplied from the gas supply take-off point at the Richards bay harbour to the power station using a gas pipeline. The natural gas will pass through a supply conditioning system before it is used in the gas turbine. Waste water produced on site will be temporary retained at a water retention dam for treatment.

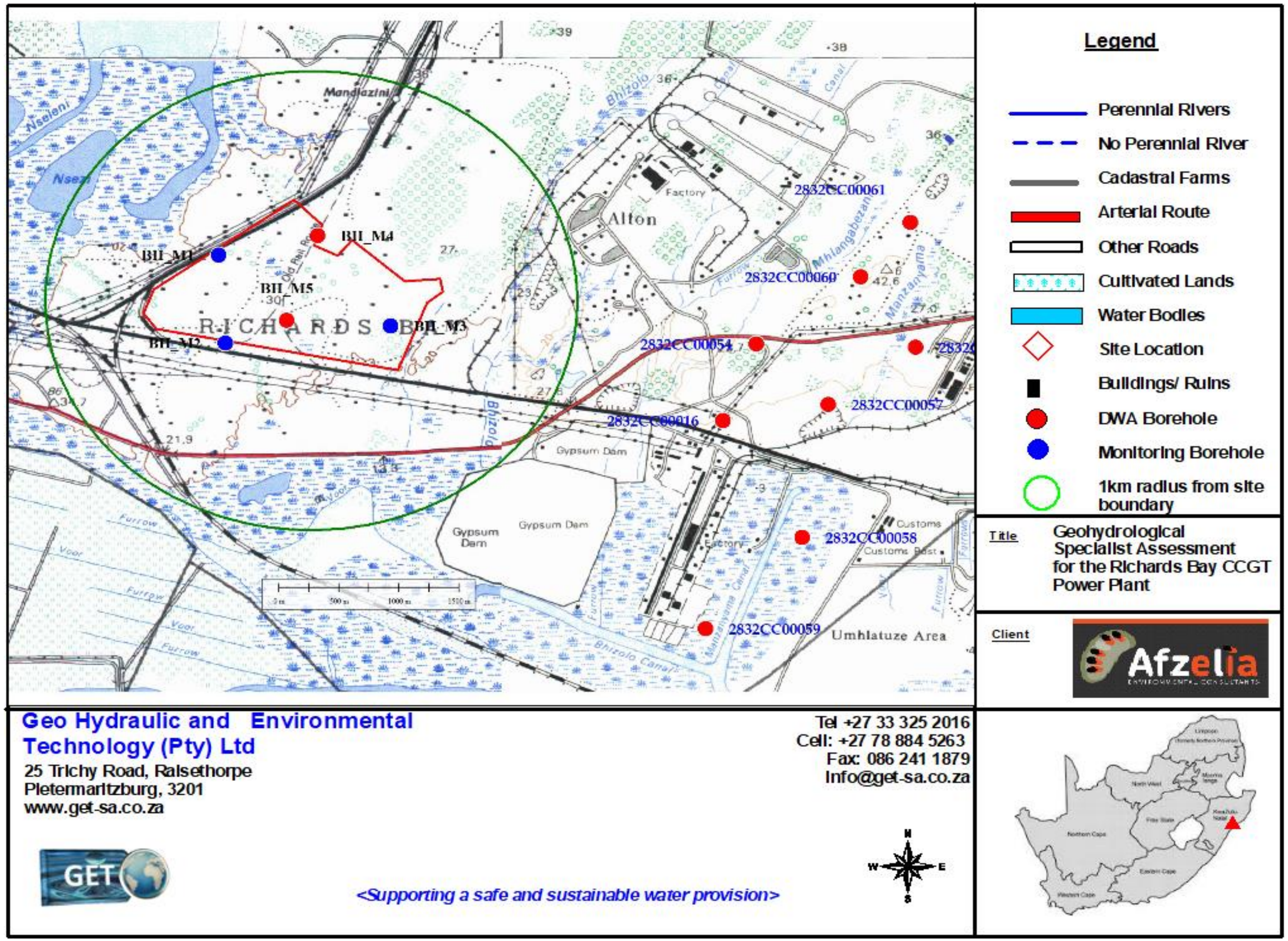


Figure 3-1 Topographic map showing the location of the site and surroundings[1]

[1] The updated layout is not shown in the map, however the same assessment study area which covers Erf 2/11376 and Erf 4/11376 is applicable.

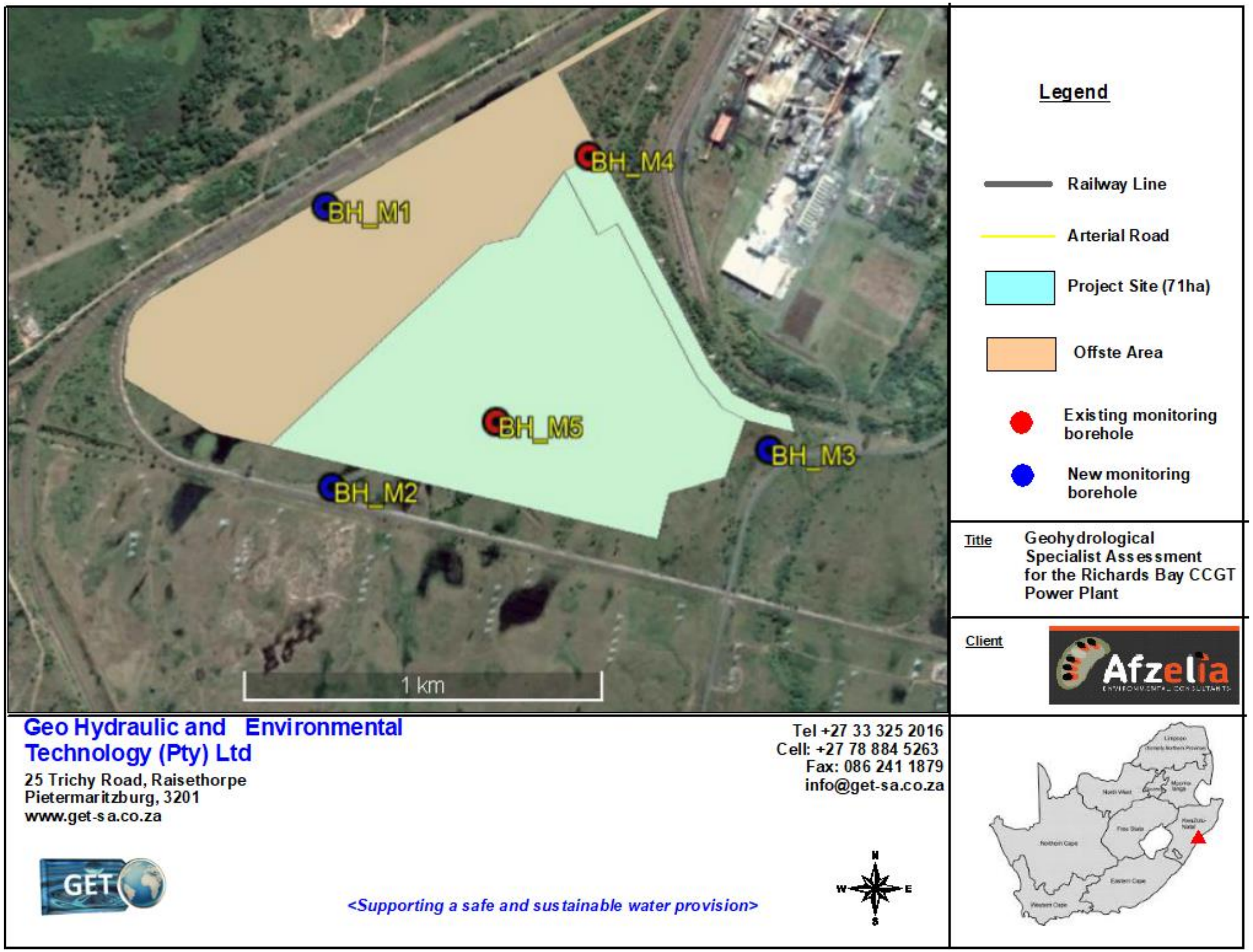


Figure 3-2 Orthographic map showing the location of the site and surroundings

3.4 Topography and Drainage

The site area lies at an elevation ranging approximately from 20 to 30 meters above mean sea level meters (m amsl). Wetland areas are present within site and a non-perennial stream located east of the site. Surface water bodies are found north west of the site including Lake Nsezi and an unnamed lake located south of the site.

3.5 Geology

According to the 1:250 000 Geological series 28(1/2)30 St Lucia (Map sheet 2830) and 1:250 000 Geological series 2830 Dundee, the site is underlain mainly by quaternary formations Qs (yellowish redistributed sand) as shown in *Table 3-2.*

The regional geology of the Richards Bay area consists of siltstone and sandstone of the St Lucia formation which is the upper part of the Zululand group. The Zululand group is overlain by red sand, red calcarenite, coquina and calcareous sandstone of Uloa formation. The Uloa formation is overlain by mudstone, shale, sandstone, lignite and sand of the Port Durnford formation. The latest is finally overlain by quaternary yellowish distributed sand. A simplified regional lithostratigraphy is shown in *Table 3-2* below.

Table 3-2: Simplified lithostratigraphy of the site

Period	Series	Stage	Group	Formation	Lithology
Quaternary	Holocene (Recent)				Alluvium, dune, aeolian and beach sands
	Pleistocene	Upper Pleistocene		Kwambonambi	Sand and aeolianite, dune and beach sand
		Middle Upper Pleistocene		Bluff	Calcareous sandstone
		Lower Pleistocene		Upper Port Dunford	Sand and sandstone
					Lignite
				Lower Port Dunford	Mudstone, clay rich sandstone
Tertiary	Late Miocene to Pleistocene			Uloa	Calcareous sandstone and coquina
	Miocene		Zululand	Richards Bay	Siltstone and sandstone
Cretaceous		Senonian		St. Lucia	Siltstone and sandstone

The two geological maps reviewed do not indicate any geological structures including faults, joints and lineaments within the study area (Refer to Figure 3-3).

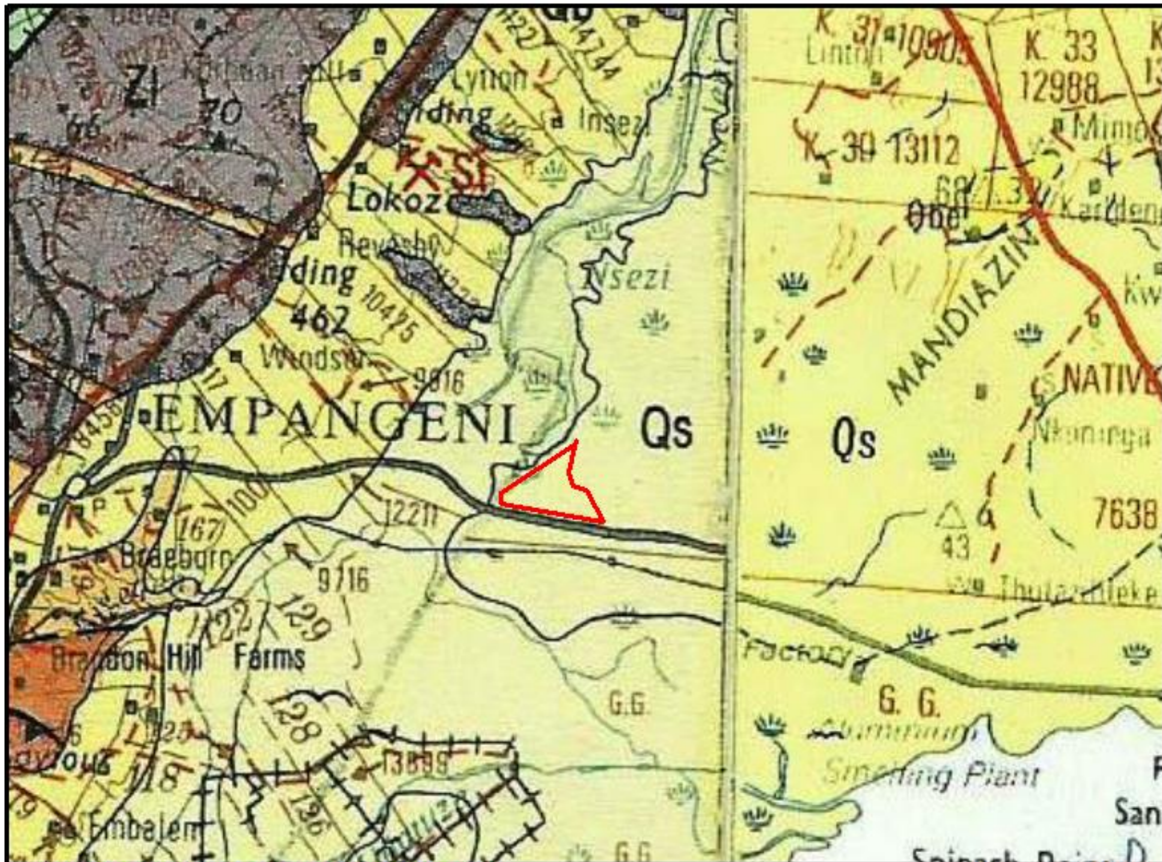
National Groundwater Archive (NGA) data reveals the lithostratigraphy data from three boreholes namely 2832CC00016, 2831DB00020 and 2831DB00006 identified within 5km radius of the site. The borehole 2832CC00016 indicates shallow granite located at 2.44mbgl overlain by a thin layer of soil, borehole 2831DB00006 indicates shallow consolidated sandstone located at 0.30mbgl underlain by conglomerate and dolerite. The borehole 2831DB00020 reveals 30m thick soil underlain by sandstone and dolerite. Referring to the position of each borehole, shallow consolidated rocks (granite and/or sandstone) are likely to be underlying the site.

During site assessment, two existing boreholes namely BH_M4 and BH_M5 were identified on site during Hydrocensus survey. Three new monitoring boreholes namely BH_M1, BH_M2 and BH_M3 were drilled and installed at 10.60 mbgl on the 16th February 2018. Boreholes details are provided in Appendix A.

From these on-site boreholes, it was determined that the local and shallow geology consisted essentially of sand, sandy clay and clayey sand formation up to 10.60mbgl.

Geophysical investigation was undertaken on site on the 15th February 2018 using magnetic method. The use of a proton magnetometer (Mag) allows to measure the earth magnetic field. Anomalies detected in the earth's magnetic intensity (in Nano Tesla) was interpreted to identify the presence of intrusive rocks (for example, dolerite dykes and sills) and their contacts zones with country rocks. Magnetic data are provided in Appendix B.

From the magnetic survey it was observed that geological interfaces and intrusive rocks are present in within the site boundaries. Based on the geological logs from newly drilled boreholes, it is anticipated these geological structures picked up by magnetic survey are located deeper than 11mbgl.



Legend

Qs	Yellowish sand
Qp	Mudstone, shale, sandstone, lignite
(red outline)	Site Location (Approximately)

Title: Geohydrological Specialist Assessment for the Richards Bay CCGT Power Plant

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Figure 3-3 1:250 000 scale geological map for St Lucia and Dundee (Map sheet 2830)

3.6 Geohydrology

3.6.1 Aquifer Characteristics

According to the 1:500 000 scale hydrogeological map series (Vryheid, Map sheet 2730) and from available hydrogeological information, Richards Bay groundwater occurs within the inter-granular primary aquifer in the semi consolidated and unconsolidated materials deposited during the Tertiary and Quaternary periods.

According to Golder (2014) the depths of boreholes measured within the Richards Bay area varies from 30 and 45 metres below ground level (mbgl) and the aquifer testing conducted indicated the hydraulic conductivity ranging from 0.5 to 5 m/d.

It was also indicated that mean annual rainfall in the Richards Bay area ranges between 994 and 1500 millimetres per year (mm/year) and the mean annual evaporation ranges from 1410 to 1923 mm/year, Germishuyse (1999). The effective groundwater recharge is estimated to range from 450 to 750mm/year. Generally, it is expected that the groundwater table mimics the surface topography. According to SRK (2008), the static water level estimated along the servitude route in the vicinity of the site varies from <2mbgl to 4mbgl.

Geohydrological data shown in Table 3-3 was obtained during the Hydrocensus survey, with drilling and testing of the new and existing on-site boreholes on the 16 February 2018. Data from NGA database for three boreholes located within 5km radius from the site are included.

Table 3-3: Data obtained from Hydrocensus survey, drilling, testing and NGA

NGA Borehole	Latitude	Longitude	pH	EC (mS/m)	Static Water Level (mbgl)	Water Strike depth to top (mbgl)	Hydraulic Conductivity (m/d)	Aquifer Lithology
BH_M1	-28.76554	31.97863	NA	NA	3.11	3.00	NT	Sand
BH_M2	-28.77231	31.97911	6.16	35	3.42	3.00	0.235	Clayey Sand
BH_M3	-28.77098	31.99152			0.64	1.00	NT	Sand
BH_M4 (2831DDV1496)	-28.76406	31.98606	6.18	35	3.85	NA	0.221	NA
BH_M5 (2831DDV1493)	-28.77057	31.98372	4.47	17	3.89	NA	0.312	NA
2832CC00016	-28.77825	32.01648	NA	NA	NA	24.38	NA	Granite (Highly weathered)
2831DB00020	-28.74351	31.97477	NA	NA	NA	28.96	NA	Sand
2831DB00006	-28.73935	31.95755	NA	NA	NA	37.80	NA	Dolerite

NA: Not Available
NT: Not Tested

Table 3-3 geohydrological data indicated that there are two types of aquifers underlying the site including a shallow primary aquifer and a deep fractured aquifer. The current site groundwater level within the shallow primary aquifer varies from 0.64 to 3.89 mbgl. It is anticipated that a fractured aquifer underlying the site is likely to be located at more than 11 mbgl.

3.6.2 Aquifer Testing

Slug tests were performed on the 16th February 2018 at three of the monitoring boreholes namely BH_M2, BH_M4 and BH_M5 to determine the site-specific hydraulic conductivity beneath the site. In performing a slug test, the static water level in a borehole is suddenly lowered or raised by lowering a closed cylinder into the borehole. This is followed by the measurement of the recovery of the water level within the borehole using a dipmeter and a stopwatch.

Hydraulic conductivities determined for three boreholes using FC method will cover the entire hydraulic conductivity range across the site. As shown in *Table 3-3,* the hydraulic conductivity (K) of the groundwater beneath the site was calculated to be 0.235 m/d, 0.221 m/d and 0.312 m/d from BH_M2, BH_M4 and BH_M5 respectively. It is likely the hydraulic conductivity at any point on the site will generally fall within this range.

The aquifer transmissivity (T) value of 1.97m2/d was determined as a product of an average K value and an estimated thickness saturated shallow portion of the shallow aquifer (7.7m).

3.6.3 Groundwater Usage - START

Germishuyse (1997) indicated that there were no groundwater extractions in the Richards Bay area, since private boreholes were prohibited by the uMhlathuze Municipality by-laws. The uMhlathuze Local Municipality Water Services By-laws 2010 allowed the sinking of abstraction boreholes only above the 50m mean sea level contour line. The recorded NGA data reviewed within 5 km radius of the site did not indicate groundwater abstractions.

During the Hydrocensus survey, it was observed that a non-perennial stream which can be found at east of the site is likely to be interacting with the shallow primary aquifer during rainy seasons. This was observed at borehole BH_M3 (static water level of 0.64mbgl) located in the close proximity of the stream.

3.6.4 Groundwater Flow Direction

Groundwater levels measured in the five boreholes were used the determine a groundwater level elevation contour map as shown in Appendix C. The map indicated that the site has two hydraulic gradients, one slopping towards west and the other toward east. Therefore, the groundwater flows both easterly and westerly with a possible divide in the central area.

Generally, groundwater flow mimics topographic levels and groundwater likely flows towards the Nsezi lake to the west and towards the non-perennial streams located to the east of the site.

3.6.5 Groundwater Quality

The 1:500 000 scale hydrogeological map (Vryheid, Map sheet 2730) indicates that electrical conductivity (EC) ranges from 0 to 70mS/m.

Groundwater sampling was conducted on-site during the Hydrocensus survey. One sample was taken from a newly drilled borehole namely BH_M2 and two samples from existing boreholes namely BH_M4 and BH_M5. These three boreholes were then purged using a bailer until electrical conductivity (EC) and pH stabilised to within 10% in each borehole. Three groundwater samples were collected and transferred to bottles provided by Talbot & Talbot laboratory and were submitted to be analysed for abridged SANS 241:2015 guidelines and for total petroleum hydrocarbon (TPH). Results are shown in Appendix D.

The results indicated that newly drilled borehole contained a certain concentration of TPH while in the two existing boreholes it was not detected. The presence of TPH in the new borehole is likely to originate from drilling tools used. This need to be confirmed through a second groundwater sampling run.

It is anticipated that the chemical constituents from the three boreholes are compliant to SANS 241:2015 guidelines except for Total Coliforms, iron, E-coli, Colour, Standard plate count and turbidity as shown in red font in *Table 3-4.*

Table 3-4 Analytical results of water samples collected in boreholes

Constituents	Units	SANS 241:2015	Analytical results		
			BH_M2	*BH_M4*	*BH_M5*
Chloride	mg Cl/l	< 300	38	69	31
Colour*	mg Pt-Co/l	< 15	22	<1	<1
Copper	µg Cu/l	< 2000	3#	3#	3#
Dissolved calcium	mg Ca/l	Not specified	4.09	6.36	0.91
Dissolved magnesium	mg Mg/l	Not specified	6.76	5.3	2.55
E. coli	colonies per 100ml	0	174	0	0
Electrical conductivity at 25°C	mS/m	< 170	35	36	161
Fluoride	µg F/l	< 1500	<50	<50	80
Free chlorine*	mg Cl2/l	< 5	0.11	<0.1	0.12
Iron	µg Fe/l	Chronic: < 2000; Aesthetic:<300	8 900#	<50#	<50#
Lead	µg Pb/l	< 10	<0.5#	<0.5#	4#
Manganese	µg Mn/l	Chronic: < 400; Aesthetic:<100	85#	7#	57#
Nitrate*	mg N/l	< 11	<0.1	1.9	0.81
Nitrite*	mg N/l 6	< 0.9	0.11	0.1	0.12
Combined Nitrate + Nitrite (sum of Ratios)*		<1	0.13	0.3	0.21
pH at 25°C	pH units	5.0 - 9.7	4.9	5.9	5.1
Sodium	mg Na/l	< 200	33	45	19.9
Standard plate count	colonies per ml	<1000	>10 000	4 640	3 080
Sulphate	mg SO4/	Acute: < 500, Aesthetic:<250	66	11.8	11.4
Total alkalinity	mg CaCO3/l	Not specified	9	22	5
Total coliforms	colonies per 100ml	<10	2700	130	156
Total hardness* m	mg CaCO3/	Not specified	38	38	12.8
Total Petroleum Hydrocarbons C10-C28 (DRO)*	µg/ℓ	Not specified	1000#	<382#	<382#
Turbidity	NTU	Operational <1; Aesthetic<5	93	6.8	4.8

The chemistry data is also interpreted to identify water type within the site area using stiff diagrams and piper diagram.

The piper diagram shown in *Figure 3-4* and the Stiff diagrams shown in *Figure 0-1* reveal that the groundwater is characterised by two hydrochemical facies including calcium-sulphate (Ca-SO_4) and sodium-chloride (Na-Cl).

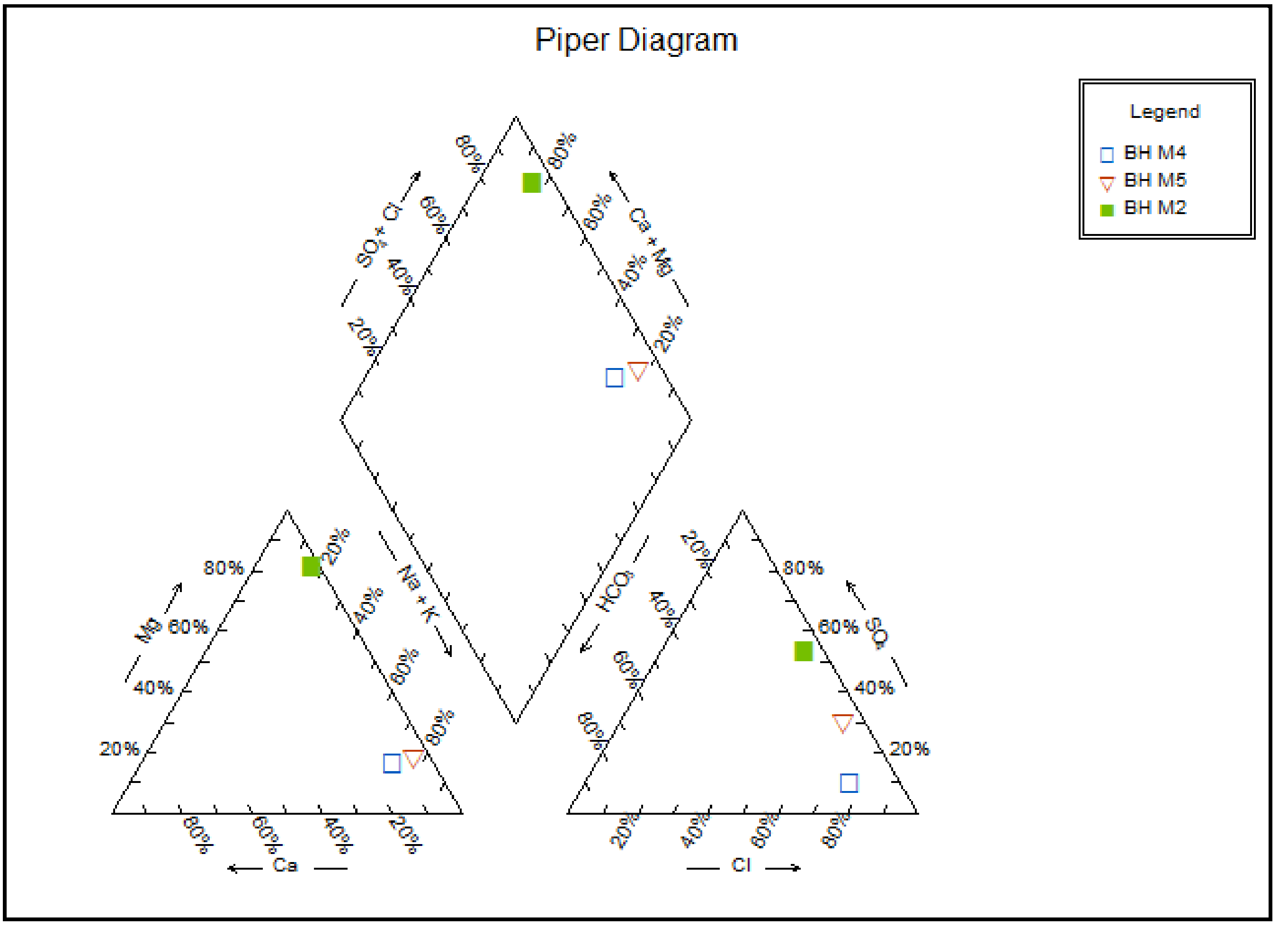


Figure 3-4 Piper diagram for groundwater

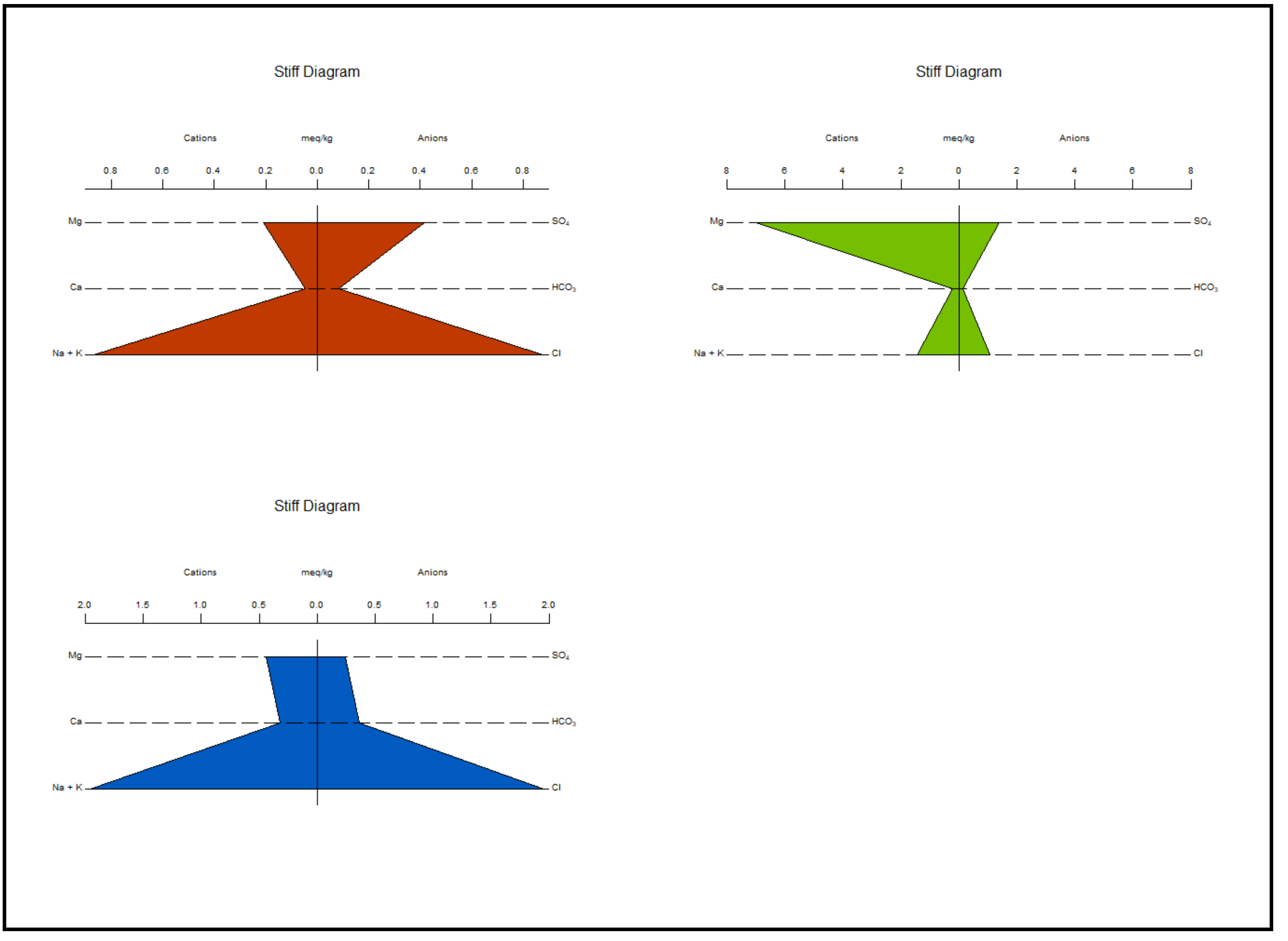


Figure 0-1 Stiff diagrams for groundwater in BH_M2 (green), BH_M4 (blue) and BH_M5 (brown)

4 Impact Identification

This impact assessment was undertaken based on the proposed project infrastructure components listed in section 3.2 and project operation described in section 3.3 above.

4.1 Limitations and Assumptions

- Due to the limited timeframe of the project, only one sampling run was performed in the rainy season. One sample collected from newly installed borehole. Ideally, additional samples should be collected during the dry season to determine an initial characterisation of the groundwater quality throughout the site.

- Water levels, lithology and hydrogeological data was not available when reviewing NGA and GRIP historical borehole data form Department of Water and Sanitation. Therefore, the estimation of the aquifer thickness and groundwater flow direction is limited.

- The department of environment at Mondi Richards bay plant located adjacent to the site was visited during the Hydrocensus survey. Groundwater levels and quality data was requested but was not made available immediately due to company policies requiring several management communications. Due to the limited timeframe of the project, no data was obtained.

4.2 Identification of Potential Impacts

The following potential impacts were identified from the desktop risk assessment within the site area:

- Groundwater flow direction will be impacted throughout the site area and will be only for the duration of the construction phase as groundwater will recover its initial conditions after completion of construction.
- Groundwater level will be lowered during the construction phase, due to dewatering to facilitate erection of building foundation, static water level being between 0.64 to 3.89 mbgl.
- During the construction phase, a potential impact exists on groundwater and surface water bodies including the Nseleni River, Nsezi dam, Voor River and Bhizolo Stream and an unnamed dam (receptors) as a result of on-site accidental fuel spills and leaks (sources) from construction vehicles and/or fuel storage areas. Fuel spills can either migrate off-site to surrounding surface water bodies by means of rain surface runoff or seep into the groundwater by means of rain water seepage (pathways).
- During the construction phase, a potential impact exists for identified receptors as a result of leachate from construction waste disposal areas (sources) and infiltration through soil (pathway) of dirty water from ablution facilities (sources).
- During the operation phase, a potential impact exists on groundwater and surface water bodies including the Nseleni River, Nsezi dam, Voor River, Bhizolo Stream and an unnamed dam (receptors) due to possible leakage of diesel and/or chemicals from storage facilities and/or pipelines and form emergency backup generators leaks (sources). With rain water seepage, hydrocarbon products (diesel) can migrate through unconsolidated formations and the reach groundwater table or migrate off-site to surface water bodies by means of rain water runoff (pathways).

- During the operation phase, a potential impact exists on identified receptors due to waste water discharges from the waste water treatment plant and pond (sources) by means of water seepage and/or rain surface runoff (pathways).
- A potential cumulative impact on groundwater quality can be expected during operation phase as a result of industrial activities form Mondi Plant located adjacent to the site.

4.3 Impact Assessment

4.3.1 Methodology

The impact rating assesses the probability, duration, extent and magnitude of an impact and assigns a rating to it. The significance weightings for each potential impact are as follows:

- < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area);
- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated); and
- > 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).

The maximum value of the environmental significant of any impact is 100.

The following scales (*Table 4-1*) is applied to each identified potential impact in section 4.3 above.

Table 4-1: Scales for potential impact rating

Extent: spatial scale	Duration: Temporal scale
0- None 1- Site only 2- Local 3- Regional 4- National 5- International	1- Very Short term: 0 to 1 year 2- Short term: 2 to 5 years 3- Medium-term: 5 to 15 years 4- Long-term: >15 years 5- Permanent: Operational life time.
Magnitude: severity	**Probability: likelihood of occurring**
0- None 2- Minor 4- Low 6- Moderate 8- High 10- Very high	0- None 1- Improbable 2- Low probable 3- Probable 4- High probable 5- Definite

The environmental significance of each identified potential impacts can be calculated using the following formula:

Significance = (duration + extent + magnitude) x probability

The identified potential impacts will need to be assess twice, before and after the implementation of any mitigation and management measures to ascertain the degree to which the potential impact can be mitigated or cause loss.
According to the potential impacts identified in Section 4.2, an impact rating is provided in *Table 4-2* below.

4.3.2 Impact Risk Rating

Table 4-2: **Significance of potential impact before mitigations**

Construction Phase				
Nature of Impact	Potential impact on groundwater flow direction due to dewatering to facilitate erection of building foundation	Potential impact on groundwater level due to dewatering to facilitate erection of building foundation.	Potential impact on surface water bodies due to on-site accidental fuel spills and leaks/leachate and infiltration of dirty water.	Potential impact on groundwater due to on-site accidental fuel spills and leaks/ leachate and infiltration of dirty water.
Duration	2	2	4	4
Extent	3	3	3	3
Magnitude	6	6	8	8
Probability	4	4	4	4
Significance	**44/ Medium**	**44/ Medium**	**60 / High**	**60 / High**
Status	Negative	Positive	Negative	Negative
Reversibility	low	Low	Low	Low
Irreplaceable loss of resources	None	None	None	None
Can impacts be mitigated	Yes	Yes	Yes	Yes
Operational Phase				
Nature of Impact	Potential impact on locale groundwater due to possible leakage of diesel from storage facilities and/or pipelines and Emergency backup generators.	Potential impact on locale surface water bodies due to possible leakage of diesel from storage facilities and/or pipelines and Emergency backup generators.	Potential impact on groundwater due to waste water and solid waste discharges.	Potential impact on surface water bodies due to waste water and solid waste discharges.
Duration	2	2	2	2
Extent	2	2	2	2
Magnitude	8	8	6	6
Probability	4	4	4	4
Significance	**48 / Medium**	**48 / Medium**	**40 / Medium**	**40 / Medium**
Status	Negative	Negative	Negative	Negative
Reversibility	Low	Low	Low	Low

Irreplaceable loss of resources	None	None	None	None
Can impacts be mitigated	Yes	Yes	Yes	Yes

Table 4-3: Mitigation Measures

Construction Phase				
Nature of Impact	Potential impact on groundwater flow direction due to dewatering to facilitate erection of building foundation	Potential impact on groundwater level due to dewatering to facilitate erection of building foundation.	Potential impact on surface water bodies due to on-site accidental fuel spills and leaks/ leachate and infiltration of dirty water.	Potential impact on groundwater due to on-site accidental fuel spills and leaks/ leachate and infiltration of dirty water.
Mitigation Measures	➢ Supervision of dewatering process by a qualified geohydrologist to ensure implementation of an appropriate pumping rate and pumping schedule; and to minimise impact extend and magnitude on groundwater condition. ➢ Supervision of excavation and erection of building foundation by qualified civil engineering team to minimise impact on groundwater condition	➢ Supervision of dewatering process by a qualified geohydrologist and excavation and pipeline installation by qualified engineering team are required to minimise impact on groundwater condition	➢ Surface and storm water run-off needs to be diverted through an oil/water separator before leaving the site. ➢ Emergency spill kits should always be present at strategic locations. ➢ Good housekeeping practices are to be implemented. ➢ Immediate reporting of significant spillages and initiate an environmental site assessment for risk assessment and remediation if necessary. ➢ Construction waste on an impermeable base, keep away from drains. ➢ Use of temporal toilets.	➢ Storage of fuel, oils and chemicals on an impermeable base, keep away from drains. ➢ Emergency spill kits should always be present at strategic locations to be used. ➢ Good housekeeping practices are to be implemented. ➢ Report significant spillages and initiate an environmental site assessment for risk assessment and remediation if necessary. ➢ Construction waste on an impermeable base, away from drains. ➢ Use of temporal toilets.

Operational Phase				
Nature of Impact	Potential impact on locale groundwater due to possible leakage of diesel from storage facilities and/or pipelines and Emergency backup generators.	Potential impact on locale surface water bodies due to possible leakage of diesel from storage facilities and/or pipelines and Emergency backup generators.	Potential impact on groundwater due to waste water and solid waste discharges.	Potential impact on surface water bodies due to waste water and solid waste discharges.
Mitigation Measures	➢ The site should be paved to avoid direct contact with impacted soils. ➢ Good housekeeping practices are to be implemented. ➢ Immediately report significant spillages and initiate an environmental site assessment for risk assessment and remediation if necessary.	➢ Good housekeeping practices are to be implemented. ➢ Immediately report significant spillages and initiate an environmental site assessment for risk assessment and remediation if necessary. ➢ Surface and storm water run-off need to be diverted through an oil/water separator before leaving the site. ➢ Regular integrity tests on fuel storage tanks and pipelines to prevent leak occurrence	➢ Regular quality monitoring of waste before discharge. ➢ Compliance to appropriate construction standards of the waste storing and drainage systems. ➢ Implementation of procedures for storage and handling hazardous substances. ➢ Solid waste must be collected and disposed of at an appropriate municipal waste disposal site. ➢ The pond needs to be lined to prevent any seepage of waste water.	➢ Regular quality monitoring of waste before discharge. ➢ Compliance to appropriate construction standards of the waste storing and drainage systems. ➢ Implementing of procedures for storage and handling hazardous substances. ➢ Solid waste must be collected and disposed of at an appropriate municipal waste disposal site.

Table 4-4: Significance of potential impact after mitigations

Construction Phase				
Nature of Impact	Potential impact on groundwater flow direction due to dewatering to facilitate erection of building foundation	Potential impact on groundwater level due to dewatering to facilitate erection of building foundation.	Potential impact on surface water bodies due to on-site accidental fuel spills and leaks/leachate and infiltration of dirty water.	Potential impact on groundwater due to on-site accidental fuel spills and leaks/ leachate and infiltration of dirty water.
Duration	2	2	2	2
Extent	2	2	1	1
Magnitude	4	4	2	2
Probability	4	4	2	3
Significance	**32 / Medium**	**32 / Medium**	**10 / Low**	**15 / Low**
Status	Negative	Positive	Negative	Negative
Reversibility	Low	Low	High	High
Irreplaceable loss of resources	None	None	None	None
Can impacts be mitigated	Yes	Yes	Yes	Yes
Operational Phase				
Nature of Impact	Potential impact on locale groundwater due to possible leakage of diesel from storage facilities and/or pipelines and Emergency backup generators.	Potential impact on locale surface water bodies due to possible leakage of diesel from storage facilities and/or pipelines and Emergency backup generators.	Potential impact on groundwater due to waste water and solid waste discharges.	Potential impact on surface water bodies due to waste water and solid waste discharges.
Duration	2	2	2	2
Extent	1	2	1	2
Magnitude	6	2	4	2
Probability	2	2	2	2
Significance	**18 / Low**	**12 / Low**	**14 / Low**	**12 / Low**
Status	Negative	Negative	Negative	Negative
Reversibility	low	Low	Low	Low

Irreplaceable loss of resources	None	None	None	None
Can impacts be mitigated	Yes	Yes	Yes	Yes

Cumulative	Mondi Plant activities adjacent to the site could be regarded as a source of potential cumulative impact on groundwater quality. The environmental management plan need to be implemented from both activities in order to expect a low impact significance. This need to be investigated further.

5 Proposed Monitoring Plan and Recommendations

A groundwater monitoring plan is required to prevent the CCPP activities from negatively impacting the groundwater quality and quantity. As part of the monitoring plan to be included in the environmental management plan the following actions are required:

- Site groundwater monitoring network will consist of background monitoring borehole (BH_M2) and two impact monitoring borehole as early warning of groundwater contamination (BH_M1 and BH_M3).
- A second groundwater sampling run and groundwater levels measurements during dry season need to be performed by a geohydrologist before construction phase for a baseline quality data characterisation.
- During operation phase, groundwater level and quality need to be monitored weekly. This will assist in detecting early contaminated groundwater migration to off-site receptors and in initiating promptly a remediation process.
- Because of groundwater and surface interaction within the study area, it is suggested that surface water monitoring of the Nsezi dam, Nseleni River, Voor River and Bhizolo stream in the vicinity of the CCPP is also undertaken to assess any impact during the construction phase and when the CCPP is operational.
- The dirty water retention dam needs to be lined to prevent any seepage of waste water.

If the monitoring data indicates that leakages have occurred, and that the groundwater system is impacted, an environmental site assessment needs to be undertaken by an appropriately qualified and experienced specialist and the necessary remediation measures taken based on the magnitude of the impact.

6 Conclusions

Based on the desktop and site geohydrological impact assessment, the following can be concluded:

- The site is essentially underlain by quaternary yellowish distributed sand which overlays the granite, conglomerate, sandstone as well as lignite and sand of the Port Durnford formation.
- A shallow groundwater occurs within the inter-granular primary aquifer in unconsolidated materials deposited during the Tertiary and Quaternary periods. The current site groundwater level within the shallow primary aquifer varies from 0.64 to 3.89 mbgl. The shallow aquifer transmissivity (T) value is approximatively 1.97m2/d. It is anticipated that a deep fractured aquifer exists below 11 mbgl.
- The site has two hydraulic gradients, one slopping towards west and the other toward east. Therefore, the groundwater flows both easterly and westerly with a possible divide in the central area.
- the chemical constituents from the three boreholes are compliant to SANS 241:2015 guidelines except for Total Coliforms, iron, E-coli, Colour, Standard plate count and turbidity. The presence of TPH in one new borehole is likely to originate from drilling tools used. This need to be confirmed through a second groundwater sampling run before construction.
- Without the implementation of any mitigation measures the significance of potential impacts to groundwater and surface water bodies at the site is high. The implementation of the mitigation measures reduces the significance rating to medium to low.

7 References

DEAT (2002) Impact Significance, Integrated Environmental Management, Information Series 5, Department of Environmental Affairs and Tourism (DEAT), Pretoria.

SRK (2008), Groundwater Baseline and Impact Assessment for Establishment of Servitudes for the Inhlansi Project, Richard Bay, Report prepared for Nozalela Mineral Sands Pty (Ltd) by SRK.

CSIR (2006), A Conservation Vision for the Freshwater Biodiversity of the Olifants, Inkomati and Usutu-Mhlathuze Water Management Areas, Directorate: Resource Directed Measures, DWA.

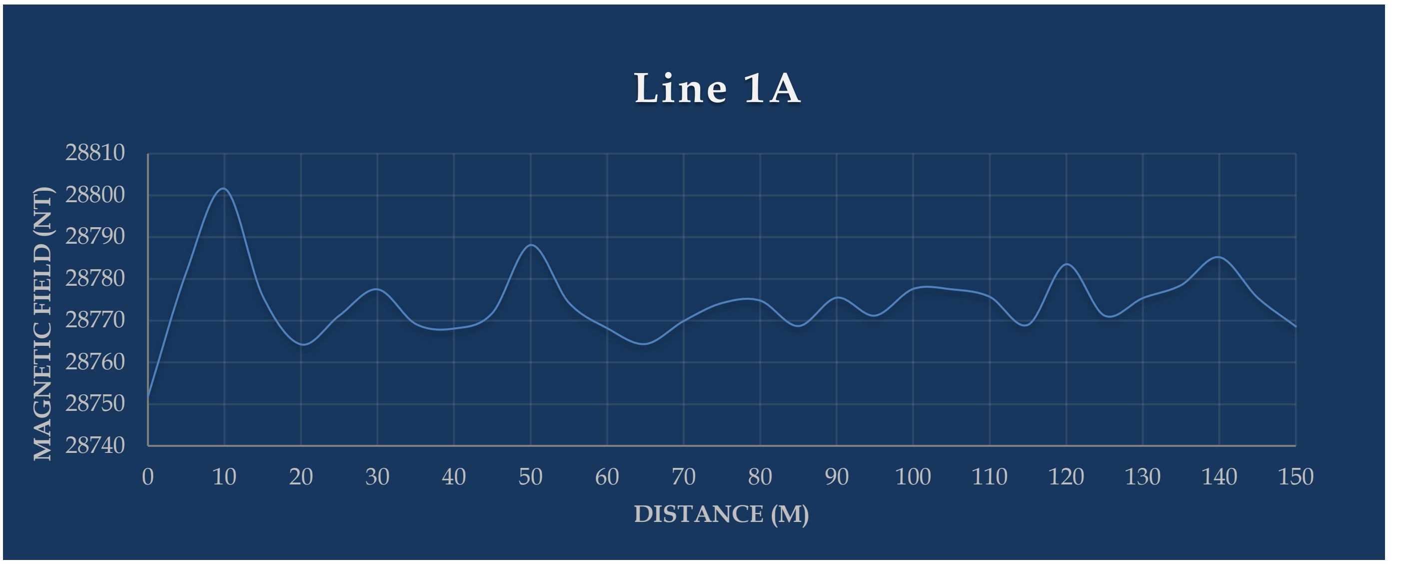
Golder Associates (2014), Zulti South-Phase I Groundwater report, Hydrocensus and information review.

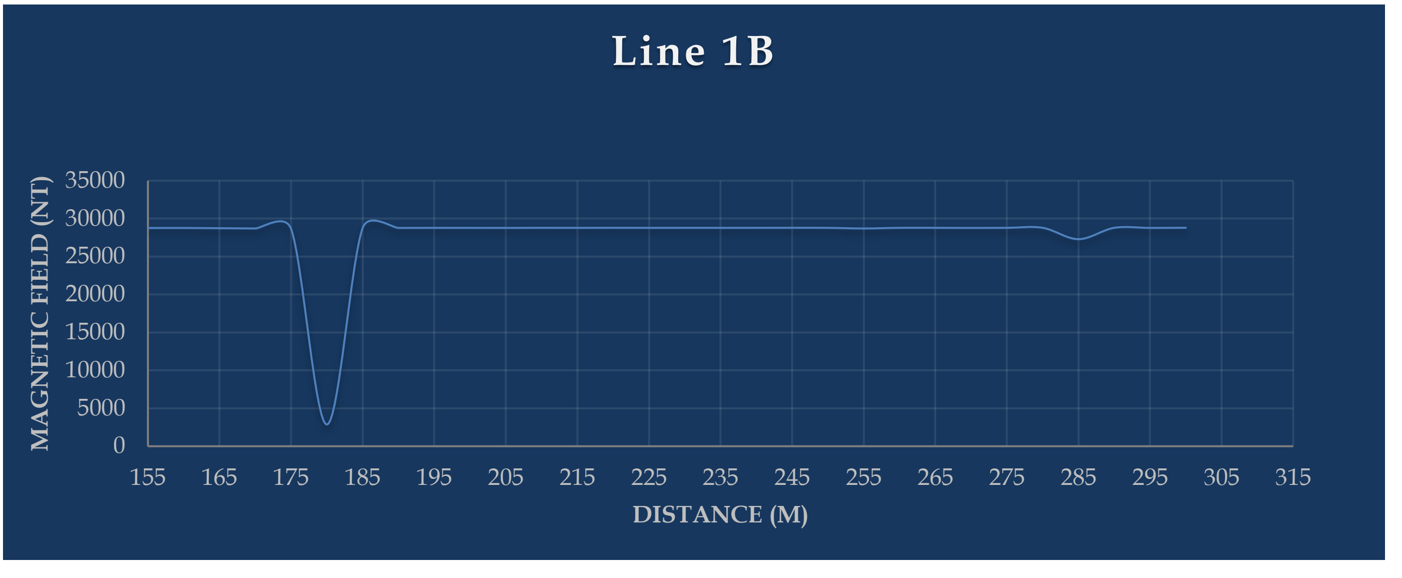
Germishuyse T, (1999), A Geohydrological Study of the Richards Bay Area, Msc Thesis.

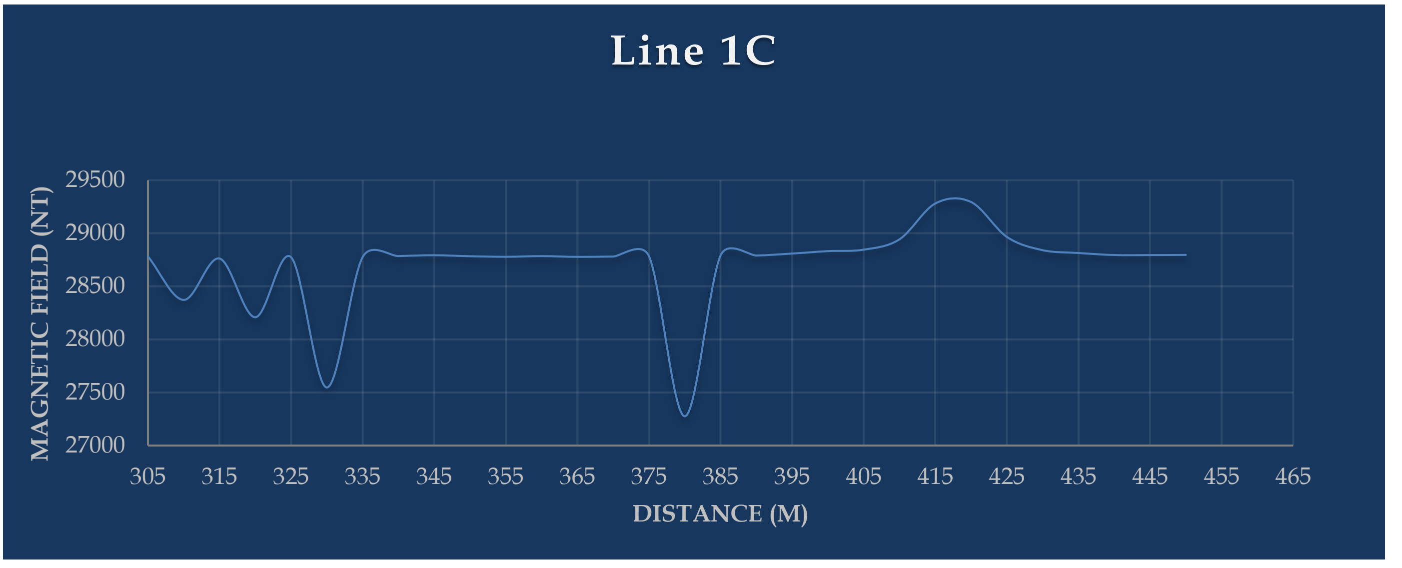
Appendix A:

Boreholes Details

Appendix B:
Geophysical Survey data



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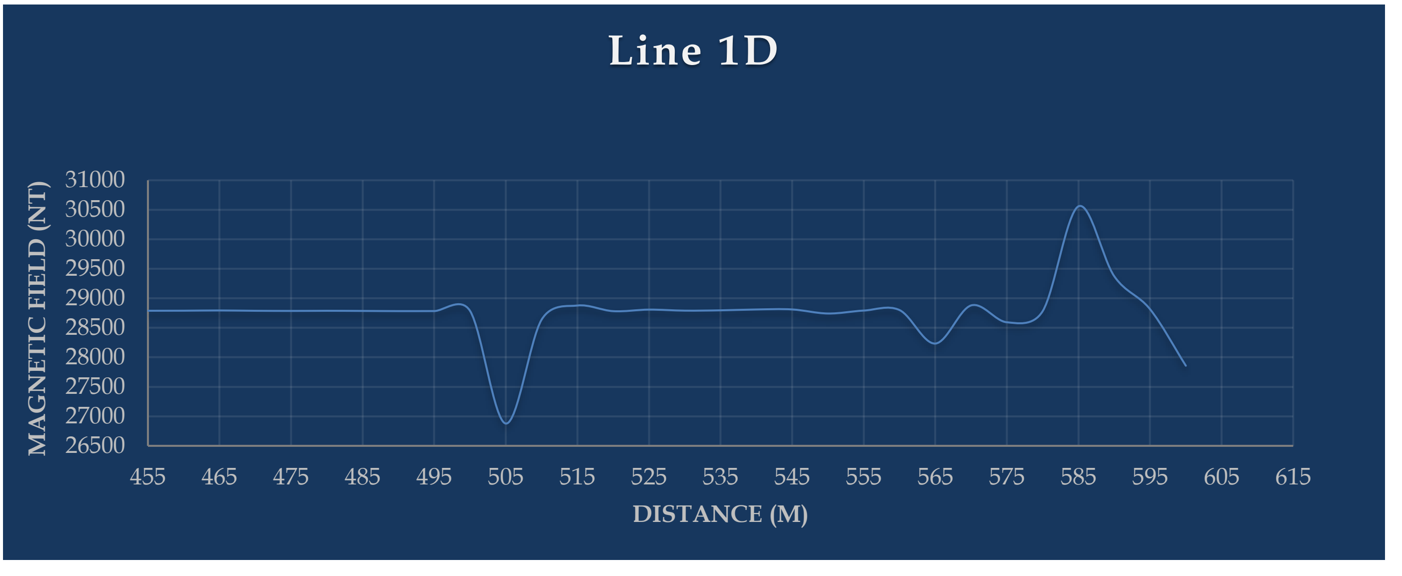
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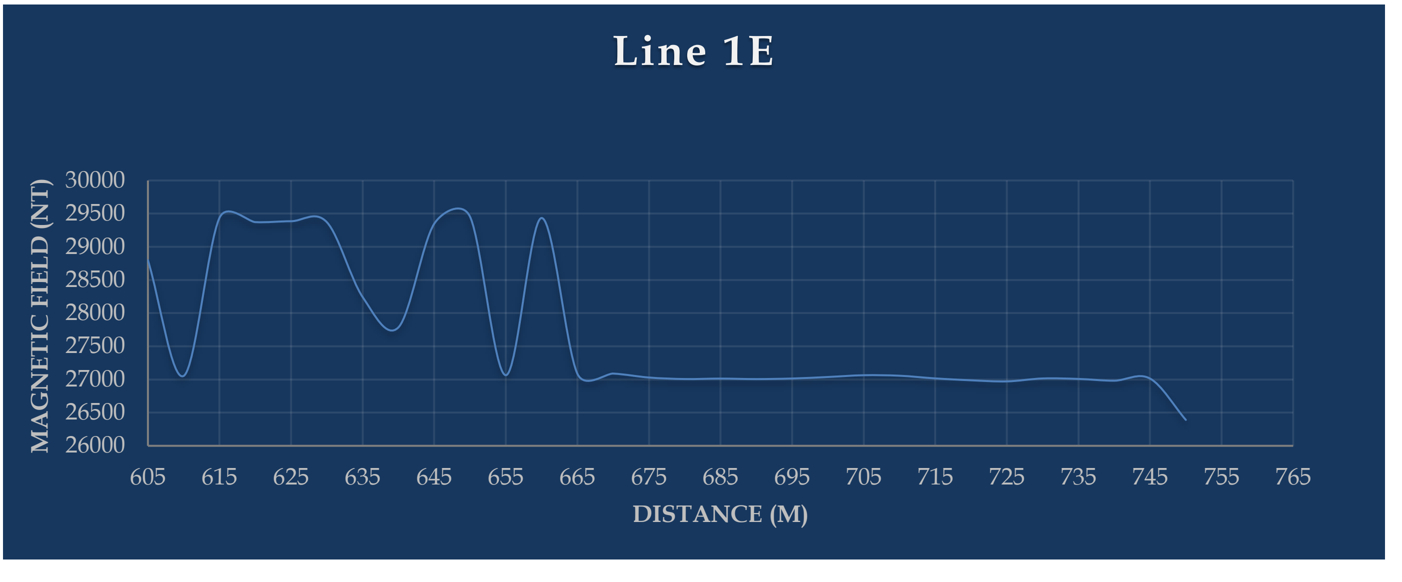
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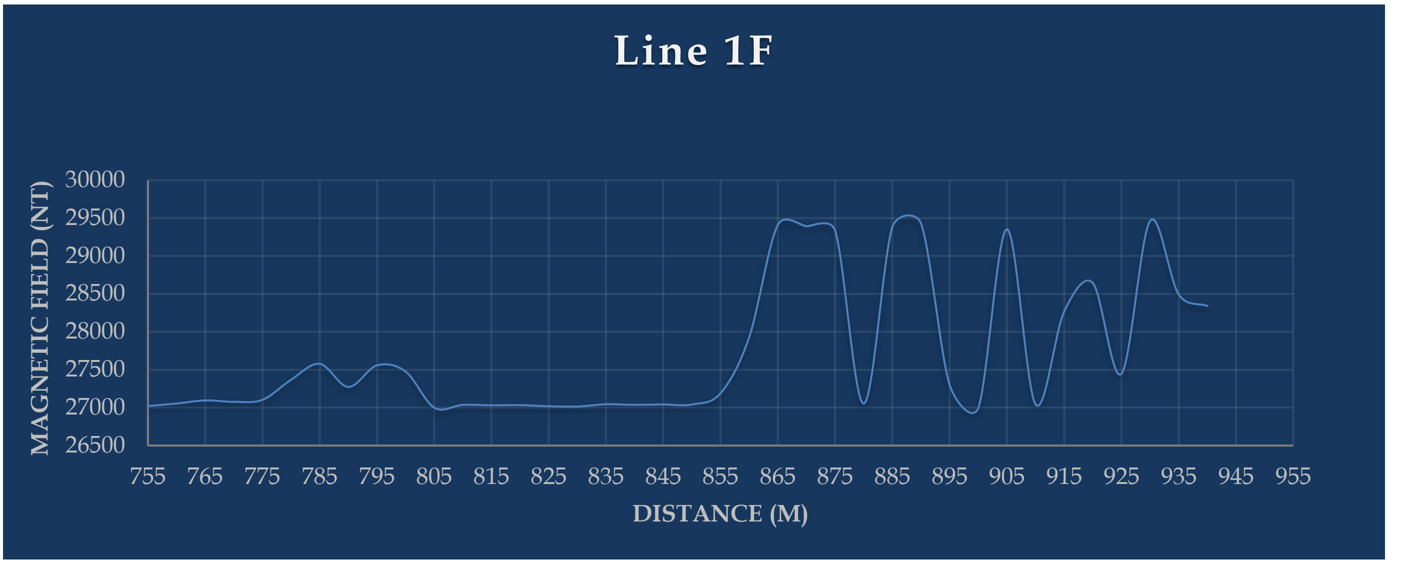
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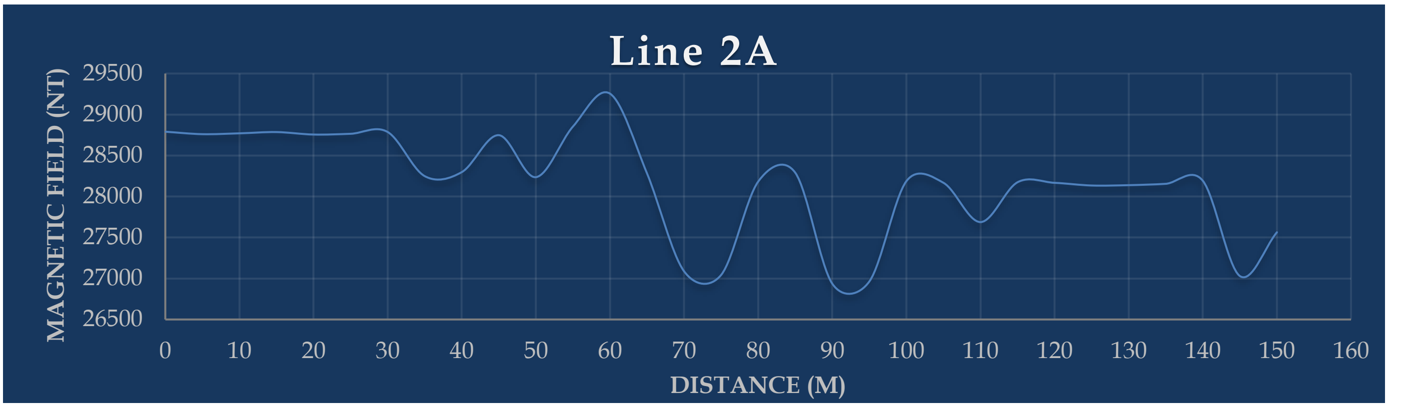
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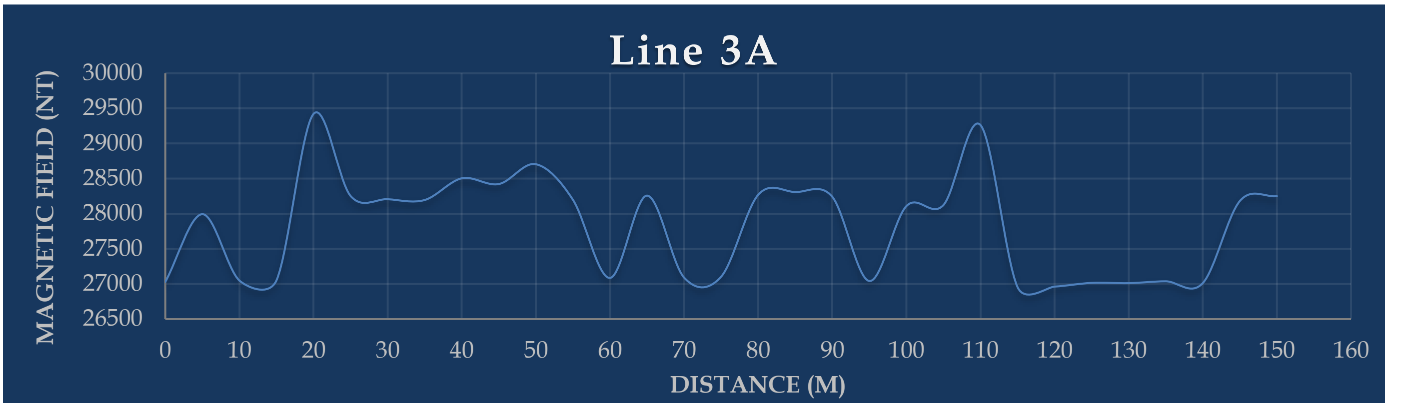
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90
100
110
120
130
140
150
160
DISTANCE (M)


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195
205
215
225
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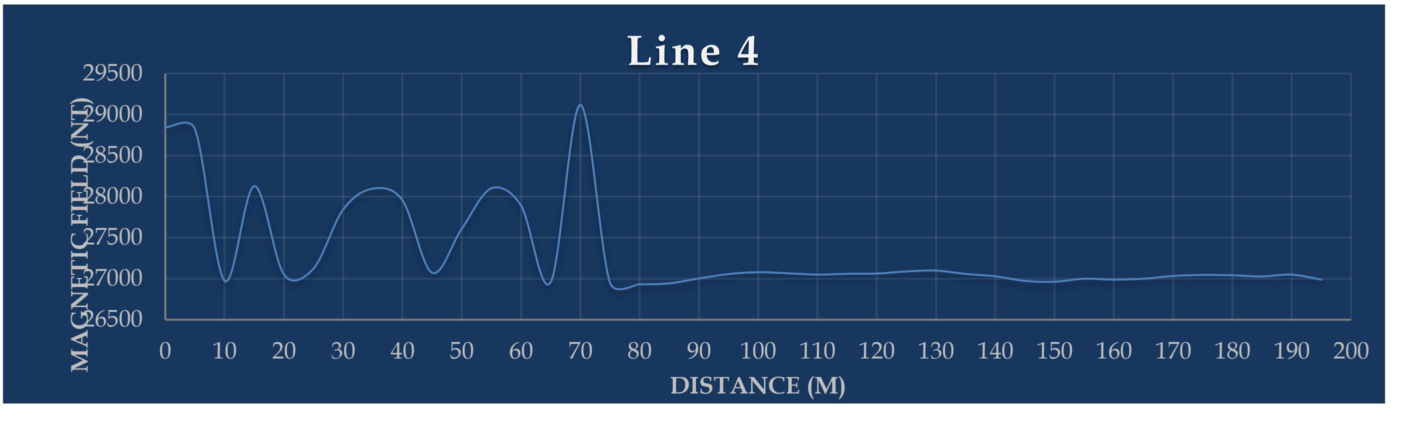
DISTANCE (M)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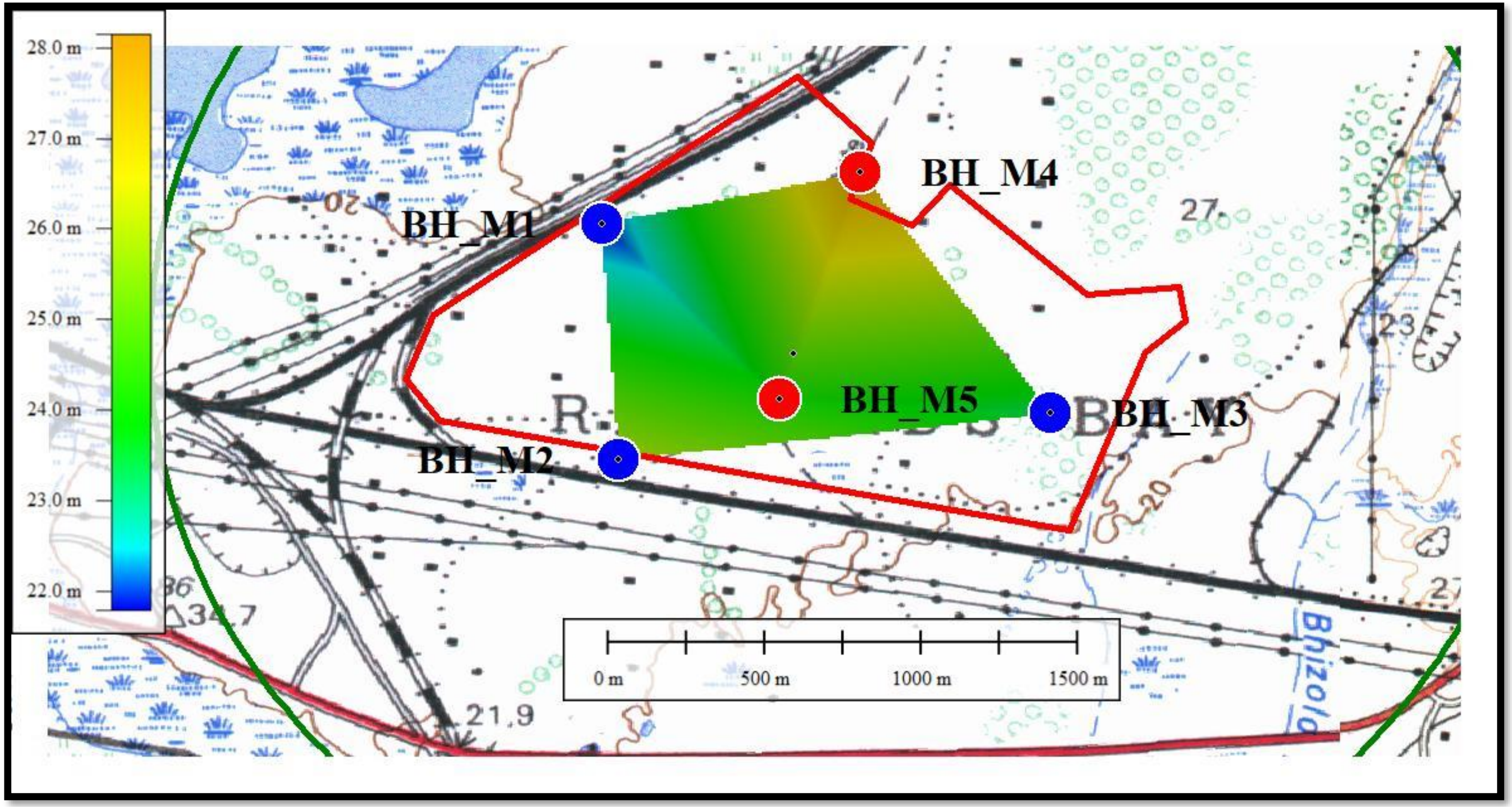
DISTANCE (M)

Appendix C:

Groundwater elevation map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22.0 m
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BH_M2
BH_M3
BH_M4
BH_M5
0 m
500 m
1000 m
1500 m

Appendix D:
Water Quality Results