Exxaro

BELFAST RELOCATION PROJECT:

GROUNDWATER EXPLORATION

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Project Title:	Belfast Relocation Project Water Supply-Groundwater Exploration
Location:	Belfast, Mpumalanga Province
Co-ordinates (WGS84):	S 25.76106° E 29.96384°
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1 INTRODUCTION

As part of the “Belfast Relocation Project”, a groundwater exploration study was required to provide the project of potable water.

The Scope of Work consisted of the following:

1. Desk study & target identification by means of interpreting an existing high resolution aerial magnetic survey of the area.
2. Borehole Siting by means of a ground geophysical survey.
3. Supervising the drilling of the boreholes.
4. Supervising the pumptesting of successful boreholes.
5. Report on the findings and management recommendations.

This report is not intended to be an exhaustive description of the exploration program, but rather a summary of the most important findings & management recommendations which should be used for the equipping of the newly drilled boreholes.

2 METHODOLGY

A phased approach was followed consisting of the following 4 phases:

2.1 Phase 1: Desk study & Reconnaissance trip

A desk study of all available geohydrological reports and data pertaining to the project area was done. A reconnaissance trip was undertaken to familiarize the project team with the area.

2.2 Phase 2: Aeromagnetic data interpretation, target identification and ground geophysical surveys for borehole siting

On completion of the desk study, a structural interpretation of existing aeromagnetic data provided by Exxaro were done by Dr Edgar Stettler from Nadir Geophysics, with the aim of identifying prospective groundwater targets.

Selected target structures picked from the airborne magnetic data was followed up on the ground by a combination of magnetic & electromagnetic techniques.

Not all of the targets picked from the airborne magnetic surveys were explored, but can be investigated during subsequent phases, should the need arise. The criteria used for selecting specific targets during this project consisted of the following:

1. Potential for yielding significant volumes of groundwater;
2. Location of targets in relation to property boundaries.

2.3 Phase 3: Drilling

After interpretation of the ground geophysical data, drilling targets were selected. Drilling was done according to the Department of Water Affairs (DWA) Guidelines for Community Water Supply. Drilling of boreholes was supervised by a qualified geohydrologist/geotechnician from Aurecon, and details such as waterstrikes, meters of casing installed, the geological profile and blow yields was recorded. Drilling supervision ensured that the boreholes was constructed and delivered according to specification.

2.4 Phase 4: Pumptesting

A first estimate of a borehole yield can be deduced from the blow yield of the borehole. This does however not represent the sustainable yield at which the borehole can be pumped. DWA Guidelines for Rural Water Supply stipulates a 48 to 72 hour constant discharge test when a borehole has a potential to yield more than 0.5 l/s and will operate for a period in excess of 8 hours per day. Forty Eight hour constant discharge tests was conducted on successful boreholes and supervised by a qualified geohydrologist/geotechnician from Aurecon to ensure that testing takes place according to the DWA Guidelines for Community Water Supply. Groundwater samples were collected towards the end of each test and submitted for a SANS 241:2006 chemical analysis to assess the water quality.

2.5 Phase 5: Reporting

A Technical Report was compiled after completion of Phases 1 - 4. This report discussed all the relevant information such as geophysical interpretations, borehole logs, pumptest and water quality interpretation and management recommendations.

3 DESK STUDY

3.1 Physiography

3.1.1 Location

The project area is located ~20km west south west of Belfast in the Mpumalanga Province on the farm Paardeplaats 425, with coordinates (S 25.760667° E 29.965690°). The site can be accessed via the unpaved road leading to Sunbury station from the N4 leading to Belfast (Map 1 - Appendix A).

3.1.2 Geology & Geohydrology

According to the 1:250 000 geological map (2528 Pretoria) (Map 2-Appendix A), the study area is underlain by sedimentary rocks of the Vryheid Formation, Karoo Supergroup. The rocks consist of sandstone, shale, gritstone, conglomerate with coal seams in places near the base and top. No geological structures (dykes, faults) are indicated on the project area.

The deposition of the Vryheid Formation sediments is largely controlled by the irregular pre-Karoo platform on which they were deposited. The pre-Karoo rocks, consisting mainly of felsites of the Bushveld Igneous Complex, have been glacially sculpted to give rise to uneven basement topography. The thin veneer sediments of the Dwyka Formation, which overlies the pre-Karoo, are generally not thick enough to ameliorate the irregularities in the placated surface, which therefore affected the deposition of the younger Vryheid Formation sediments.

The Ecca sediments consist predominantly of sandstone, siltstone, shale and coal. Combinations of these rock types are found in the form of interbedded siltstone, mudstone and coarse grained sandstone.

Dolerite/Diabase intrusions in the form of dykes and sills are present within the Ecca Group. The sills usually precede the dykes, with the latter being emplaced during a later period of tensional forces within the earth's crust. Tectonically, the Karoo sediments are practically undisturbed. Faults are rare. However, fractures are common in competent rocks such as sandstone and coal.

According to Barnard (2000), the groundwater yield potential is classed as low since 83% of boreholes on record produce less than 2 l/s. The general suitability of the groundwater for any use is indicated by the average EC value of 57 mS/m and a mean pH value of 7.5. The groundwater rest level is generally encountered between 5 and 25m below surface. This was confirmed on site where the measured average static water level was 12.41mbgl.

It can be assumed that the regional groundwater flow direction will emulate to local topography. Due to the fact that the site is situated on a water divide, groundwater flow will be in two directions, namely in a north westerly and a north easterly direction towards the intermittent stream that both flow into the Steelpoort River downstream as well as a southern direction towards the intermittent stream flowing into the Klein-Komati River.

According to Hodgson et al. (1998), three distinct superimposed groundwater systems are present within the occurring geology. They can be classified as the upper weathered Ecca aquifer, the fractured aquifers within the unweathered Ecca sediments and the aquifer below the Ecca sediments.

3.1.2.1 Ecca Weathered Aquifer

The Ecca sediments are weathered to depths between 5 – 12 meters below surface and often form a perched aquifer. This aquifer is recharged by rainfall and estimated to be between 1-3 % of the annual rainfall. Rainfall that infiltrates into the weathered rock soon reaches an impermeable layer of shale underneath the weathered zone. The movement of groundwater on top of this shale is lateral and in the direction of the surface slope. The water discharges at surface in the forms of fountains and springs where the flow paths are obstructed by a barrier, such as a dolerite dyke, paleo-topographic highs in the bedrock, or where the surface topography cuts below the groundwater table at streams. It is suggested that less than 60% of the water recharged to the weathered zone eventually emanates in streams while the remaining water is evapo-transpirated or drained by some other means.

This aquifer is generally low-yielding (100 – 2000 ℓ//h) because of its insignificant thickness. Wells or trenches dug into this aquifer are often sufficient to secure a constant water supply of excellent quality. The excellent water quality can be attributed to the many years of dynamic groundwater flow through the weathered sediments. Leachable salts have been dissolved and it is only the slow decomposition of clay particles which presently releases salts into the water.

3.1.2.2 Fractured Ecca Aquifer

The pores within the Ecca sediments are too well cemented to allow any significant permeation of water. Groundwater movement is therefore along secondary structures, such as fractures, cracks and joints in the sediments. These structures are better developed in competent rocks such as sandstone, hence the better water yielding properties of the latter rock type. It should, however, be emphasised that not all secondary structures are water bearing. Many of these structures are constricted because of compressional forces that act within the earth's crust. The chance of intersecting a water-bearing fracture by drilling decreases rapidly with depth. At depths deeper than 30 m, water-bearing fractures with significant yield were observed to be spaced at 100 m or greater. Scientific siting of production boreholes is necessary to intersect these fractures. The mean yield of this aquifer is ~1250 ℓ//h.

In terms of water quality, the fractured Ecca aquifer always contains higher salt loads than the upper weathered aquifer. Although the sulphate, magnesium and calcium concentrations in the Ecca fractured aquifer are higher than that in the weathered zone, they are well within expected

limits. The higher concentrations can be attributed to the longer exposure time of the water to the rock. The occasional elevated chloride and sodium levels can be attributed to boreholes in the vicinity of areas where salts naturally accumulate on surface, such as pans and some of the fountains.

3.1.2.3 Pre-Karoo Aquifer

Drilling in only a few instances has intersected the basement of the Karoo Supergroup which can be regarded as an insignificant aquifer due to:

- The great depth,
- Low yielding fractures,
- Inferior water quality with elevated concentrations of fluoride associated with the granitic rocks,
- Low recharge characteristics of this aquifer because of the overlying impermeable Dwyka tillite.

3.1.3 Groundwater Recharge

The study area falls within quaternary catchment B41A. The mean annual precipitation and annual recharge figures for this quaternary catchment is presented in Table 1. The values used were derived from the WR90 data set as contained in the GRDM Software (DWA and WRC).

Table 1. Rainfall & Recharge in Quaternary Catchment B41A

	B41A
Mean Annual Rainfall (mm)	715
Annual Recharge (mm)	51.88
Annual Recharge (%)	7.25

4 GEOPHYSICAL SURVEYS

Borehole siting is primarily concerned with the location of geological discontinuities, as higher borehole yields are generally associated with such features. Apart from direct geological observation, which is the most satisfactory method of borehole location where it can be practised, potential groundwater bearing discontinuities can be located either by remote sensing methods or surface geophysical methods. Both methods were used for the exploration program.

4.1 Interpretation of aeromagnetic survey data

The aeromagnetic data used in this study as the criterion to determine the measure of optimum placement of drilling targets, was flown by Exxaro as part of their geophysical survey for the Belfast coal mine.

Figure 1 depicts total magnetic field (TMF) coverage of the survey area. Increases in the magnetic field strength or ‘magnetic highs’ are portrayed as ridges or hills coloured in a (warm), reddish hue and decreases in the field strength appear as valleys or troughs and are coloured in a (cold) bluish hue.

In Figure 2 the magnetic data was overlain on an aerial image of the site. Because the exact location and dip of the identified structures was not known, it was recommended that ground

geophysical surveys be conducted. In Figure 3, the interpreted structures as well as the recommended geophysical traverses are overlain on the aerial image of the site.

4.2 Recommended Exploration Targets

Below are given the coordinates of the start and end points of the proposed traverses and the location of the traverses can be seen in Figure 2 below.

Table 2: Coordinates of the start and end points of the proposed geophysical traverses (Decimal degrees, WGS 84).

Trav. ID	Lat/Long Start	Lat/Long End	Length (m)
A-A'	S25.76080 E29.97278	S25.75980 E29.97440	160
B-B'	S25.75922 E29.97075	S25.75833 E29.97328	270
C-C'	S25.75985 E29.96490	S25.76115 E29.96685	250
D-D'	S25.75759 E29.96794	S25.75911 E29.96922	200
E-E'	S25.75709 E29.97678	S25.75616 E29.97920	260
F-F'	S25.75549 E29.98121	S25.75472 E29.98346	240
G-G'	S25.75948 E29.96276	S25.76033 E29.96378	130
H-H'	S25.75764 E29.96419	S25.75857 E29.96549	150
I-I'	S25.75531 E29.96597	S25.75653 E29.96737	190

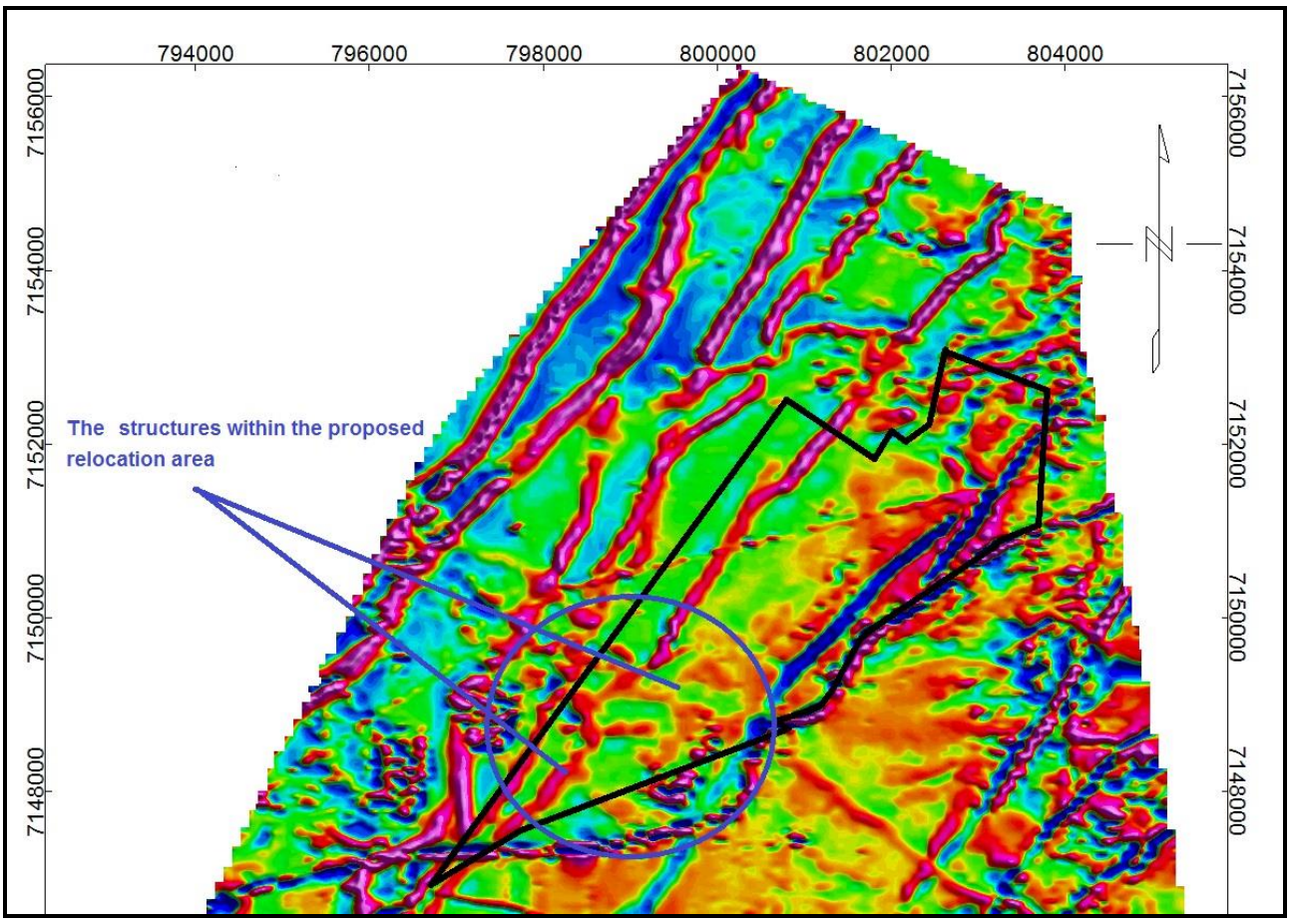

Figure 1. High resolution aeromagnetic coverage of the relocation site.

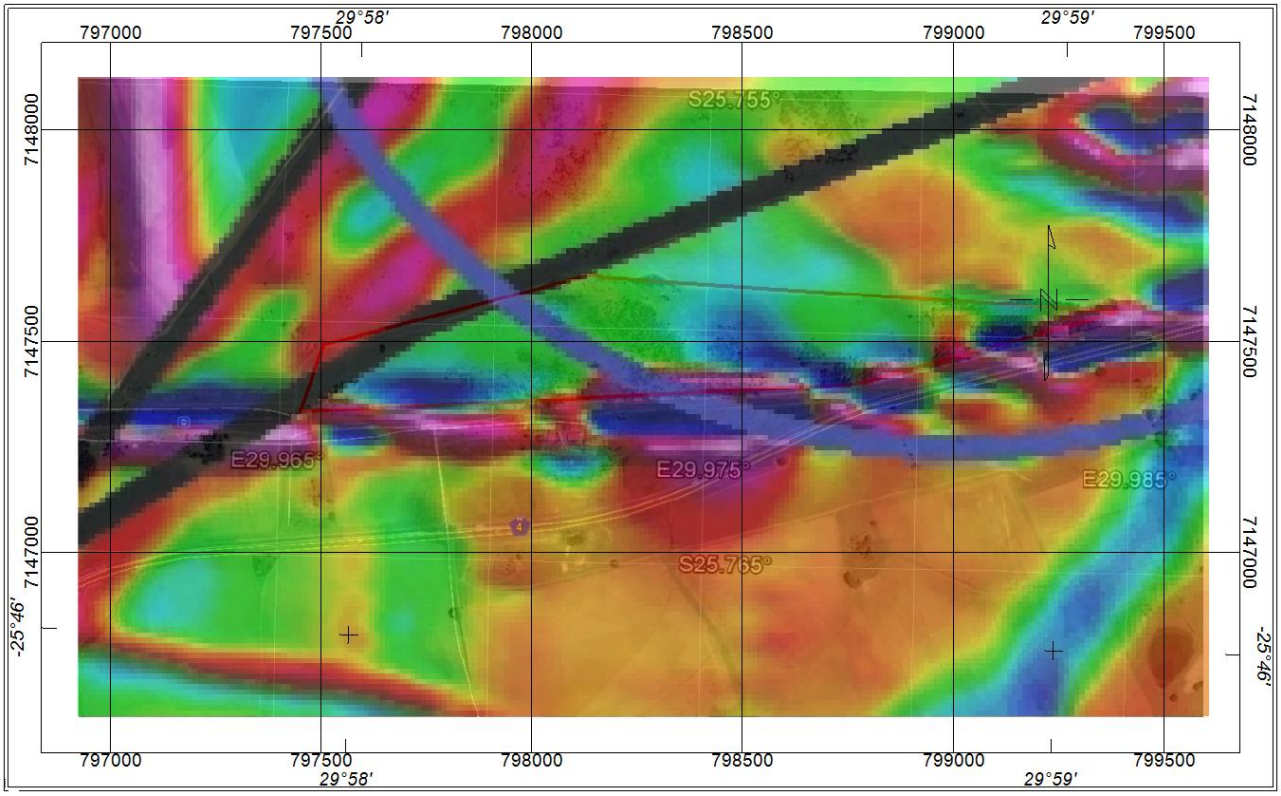

Figure 2: Aeromag data overlain over the aerial image of the site.

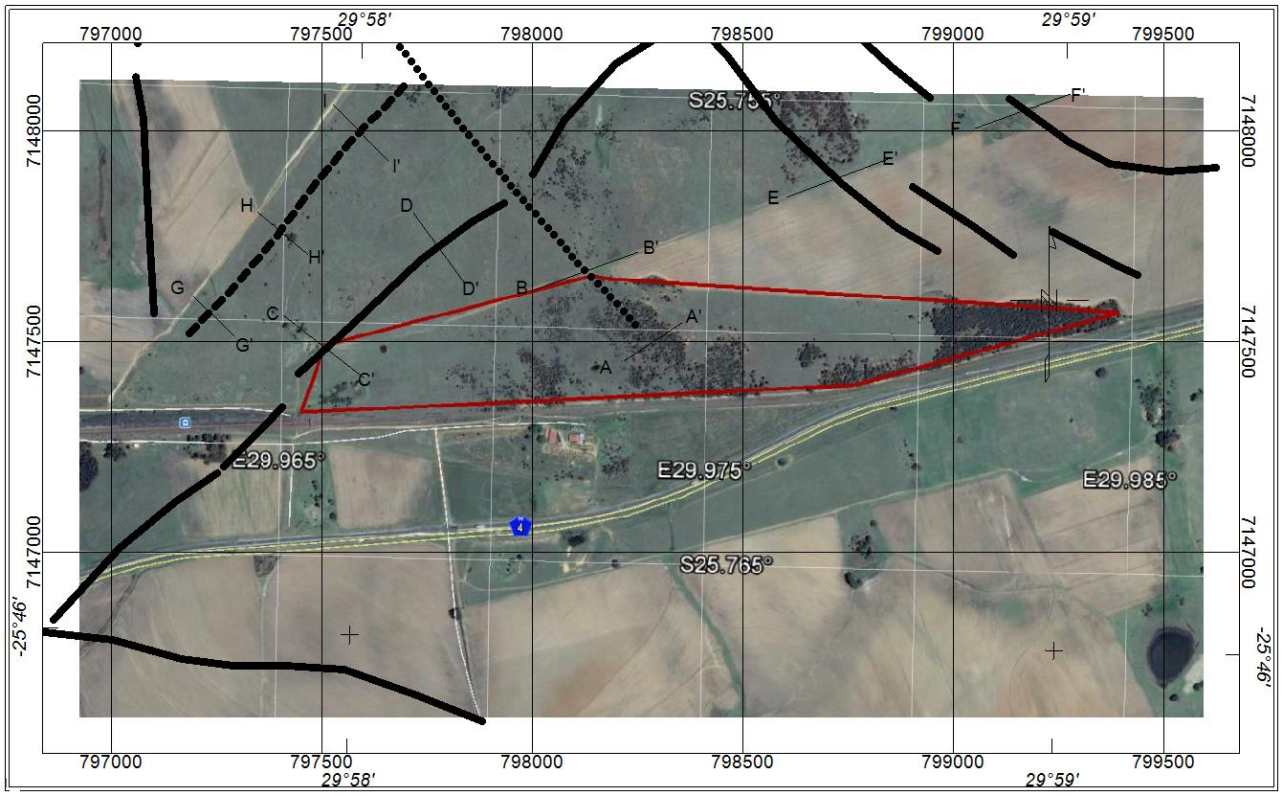

Figure 3: Aerial image of the site with the interpreted structures overlain as well as the proposed ground geophysical traverses.

After the interpretation of the aeromagnetic data of the relocation area, priority areas were selected for ground geophysical surveys. It must be stated that not all of the priority areas were investigated.

The traverses were conducted using the magnetic (Geotron G5) and electro-magnetic (Geonics EM34-3) methods. The station spacing was 10m and a coil spacing of 20 and 40m was utilised.

A total of five geophysical traverses were conducted. Data for the geophysical profiles are presented in Appendix B. After interpretation of the data, 7 drilling targets were identified of which three were drilled (Map 1 - 4 in Appendix A). The details of the ground geophysical traverses conducted are given in Table 4.

Table 3: Details of actual ground geophysical traverses conducted.

Line No	Start Coordinate (WGS84)	End Coordinate (WGS84)	Drilling Targets
Line A	S25.76082 E29.97277	S25.75918 E29.97494	~
Line B	S25.75723 E29.97228	S25.75857 E29.96996	~
Line C	S25.76044 E29.96668	S25.75881 E29.96443	Target 2 (163m); Target 7 (180m)
Line DI	S25.75913 E29.96919	S25.75607 E29.96599	Target 4 (55m); Target 5 (440m); Target 6 (480m)

Line G	S25.75949 E29.96326	S25.76146 E29.96398	~
Line H	S25.75850 E29.96541	S25.75787 E29.96452	Target 3 (53m)

5 BOREHOLE DRILLING

After completion of the geophysical survey and interpretation of the results, 6 boreholes were drilled within the allocated budget by Environmental Drilling and Remediation Services (EDRS) from Lanseria during March 2016 using an air percussion drilling rig.

All of the boreholes were drilled to a final depth of 80m. The boreholes were fitted with 3mm solid steel casing in the weathered zone and perforated where waterstrikes were encountered. The boreholes were delivered with a concrete plinth and a tamper proof cap. As requested by Exxaro, all boreholes were delivered with a concrete plinth and lockable cap to act as future monitoring boreholes.

A summary of the newly drilled boreholes are presented in Table 4 and the location of the boreholes are presented in Map 4 - Appendix A. Detailed borehole logs are presented in Appendix C.

Table 4. Summary of the newly drilled boreholes.

BH No.	S (WGS84)	E (WGS84)	Target on Geophysical Traverse	Depth (m)	Diameter (mm)	Water strikes (m)	Blow Yield (l/h)
BRBH1	25.76156	29.96534	Redrilled Existing Borehole	80	165	22	Seepage
BRBH2	25.75937	29.96526	C-180m	80	165	19	7200
BRBH3	25.75619	29.96611	DI-480m	80	165	13	7200
BRBH4	25.75947	29.96539	C-163	80	165	70	Seepage
BRBH5	25.75881	29.96888	DI-55m	80	165	9, 71	7200
BRBH6	25.75829	29.96506	H-53	80	165	21	4680

Figure 4: EDRS drilling rig established on borehole BRBH2.

6 PUMP TESTING OF SUCCESFULL BOREHOLES

Upon completion of the drilling, *AB Pumps* from East London conducted pump tests on the 3 successful boreholes. Aurecon supervised the testing to ensure that the "DWAF Standard Guidelines for Pump Testing" were adhered to.

A Step Test followed by 48 hour Constant Discharge Test & Recovery Monitoring was performed on the boreholes. Pump test data sheets are presented in Appendix F. Background information on the details of pumptesting is presented in the following paragraphs.

6.1 Description of a pumptest

The efficient operation and utilisation of a borehole requires insight into and an awareness of its productivity and that of the groundwater resource from which it draws water. This activity, which is also known as test pumping, provides a means of identifying potential constraints on the performance of a borehole and on the exploitation of the groundwater resource. It also provides data to calculate aquifer parameters such as Transmissivity (T) values.

The following tests were performed on the boreholes: (1) Stepped Discharge Test; (2) Constant Discharge Test and (3) Recovery Monitoring.

6.1.1 Stepped Discharge Test

Also known as a step drawdown test, it is performed to assess the productivity of a borehole. It also serves to more clearly define the optimum yield at which the borehole can be subjected to constant discharge testing. The test involves pumping the borehole at three or more sequentially higher pumping rates each maintained for an equal length of time, generally not less than 60 minutes. The magnitude of the water level drawdown in the borehole in response to each of these pumping rates is measured and recorded in accordance with a prescribed time schedule.

6.1.2 Constant Discharge Test

A constant discharge test is performed to assess the productivity of the aquifer according to its response to the abstraction of water. This test entails pumping the borehole at a single pumping rate which is kept constant for an extended period of time. The test duration is usually between 24 and 74 hours. In this instance, 48 hour tests were conducted.

6.1.3 Recovery Monitoring

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

7 CALCULATING THE SUSTAINABLE YIELD OF THE BOREHOLES

Data acquired during pumptesting of the boreholes was used to calculate the sustainable yield of the tested boreholes. The sustainable yield of a borehole can be defined as the discharge rate that will not cause the water level to drop below the major fracture network supplying water to the borehole. The distance between the static water level and this position is also generally referred to as the available drawdown (AD). The major water strike is obtained through observation during drilling supervision or can be more accurately detected from diagnostic plots compiled from the pumping test data. The water level in the borehole should never drop below the position of the main fracture.

The Flow Characterisation Method (more commonly referred to as the “FC-Method”) developed by the Institute of Groundwater Studies at the University of the Free State was used to calculate the sustainable yield of the boreholes. The FC-Method calculates the sustainable yield of a borehole by using recharge, derivatives, boundary information and error propagation. The results of the calculation of the sustainable yield are presented in Table 5 and the FC-Solutions in Appendix D.

Table 5. Results of the sustainable yield calculations

Borehole nr.	Depth (m)	Static Water Level (m)	Available Drawdown (m)	Sustainable Yield (l/h) Pumping 24 hours/day	Volume/day (m^3)
BRBH2	80	7.98	10.2	900	21.6
BRBH5	80	13.62	57.38	1 800	43.2
BRBH6	80	15.98	5.02	3 600	86.4
			TOTAL VOLUME/DAY (m^3)		**151.2**

Based on the available data, it can be concluded that a total volume of **151.2 m^3/day** can be abstracted from the tested boreholes.

8 GROUNDWATER QUALITY

A pumped water sample was collected from the tested borehole towards the end of the pump test and submitted to Aquatico Scientific (SANAS accredited laboratory) in Pretoria for a major cation/anion analysis. The samples were filtered and preserved and bacteriological samples were

taken using sterile made-for-purpose sample bottles. Laboratory reports of the chemical and bacteriological analysis are presented Appendix E. The analytical results were compared with the SABS drinking water standards (SANS 241-1:2015, edition 2) (Table 6). Water is classified unfit for human consumption if the Standard Limits are exceeded.

Table 6. Chemical parameters compared to SANS 241-1:2015 (edition 2) drinking water standards

Sample Nr.	BRBH2	BRBH5	BRBH6				Standard Limits
Ca	23.50	19.90	14.70				~
Mg	8.20	6.10	5.41				~
Na	9.28	8.60	7.47				200
K	5.39	4.40	4.19				~
Mn	0.02	0	0				0.1
Fe	2.43	0	0				0.3
F	0	0.27	0.16				1.5
NO_3-N	0.37	0.24	0.29				11
NH_4-N	0.09	0.01	0.07				1.5
Al	0	0	0				0.3
PO_4	0.04	0.06	0.096				-
Cl	4.8	2.7	1.2				300
SO_4	31.3	5.7	4.2				250
TDS	131	106	88				1200
T-Alk	76	95	81				~
pH	8.23	8.06	8.25				5.0 - 9.7
EC	20	18	17				170
E.Coli Count	0	0	0				0
Total Coli. Count	0	0	4				≤10
Faecal Coliform.	0	0	0				0

Notes
Yellow = Acceptable
Exceeds standard limits
0 = below detection limit of analytical technique

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

From Table 6 it can be concluded that with the exception of BRBH2 (elevated Fe concentrations) the water quality of the tested boreholes falls within the Drinking Water Standard Limits.

The occurring Iron concentrations within BRBH2 will have a pronounced aesthetic (taste and staining) effects as well as result in problems with plumbing. Slight health effects may be expected in young children and sensitive adults. High iron concentrations may result in haemachromatosis, where tissue damage occurs as a consequence of iron accumulation. Treatment includes aerating the water. Aeration results in oxygenation of the water aiding in the precipitation of iron as iron oxide.

9 MANAGEMENT RECOMMENDATIONS

Based on the desk study, field work and interpretation of available and newly acquired data, Table 7 was compiled which summarises management recommendations for the newly tested boreholes. This data should be used by the relevant engineer who is responsible for the equipping of the boreholes.

Furthermore, the following recommendations are made with regards to the management of boreholes at the Belfast Relocation Site:

- Boreholes should not be pumped at a pumping rate exceeding the calculated sustainable yield.
- Water samples for chemical analysis should be taken on a three monthly basis and water levels should be measured on a monthly basis. This would act as an early warning system. Should a sudden decrease in water levels occur, borehole yields should be adapted accordingly. Automatic borehole loggers could also be installed.
- Care must be taken not to develop and build potential pollution sources (french drains, septic tanks, pit latrines, etc.) close to and upstream from production boreholes.
- If necessary, the drilling targets not drilled during this phase can be drilled in a subsequent phase.

Table 7. Management recommendations for newly drilled boreholes

Borehole nr.	Coordinates (WGS84)		Depth (m)	Static Water Level (m)	#Dynamic WL (m)	Diameter (mm)	Sustainable Yield (l/h) Pumping 24 hours/day	Volume/day (m^3)	Proposed depth of pump installation (m)	Water Quality (SANS 241)	Comments
	S	E									
BRBH2	25.75937	29.96526	80	7.98	10	165	900	21.6	30	Exceeds Standard Limits (Fe)	Borehole ready to be equipped. Treatment required
BRBH5	25.75881	29.96888	80	13.68	20	165	1800	43.2	30	Suitable for Human Use	Borehole ready to be equipped
BRBH6	25.75829	29.96506	80	15.98	20	165	3600	86.4	30	Suitable for Human Use	Borehole ready to be equipped
					Total Volume/Day (m^3)			**151.2**			

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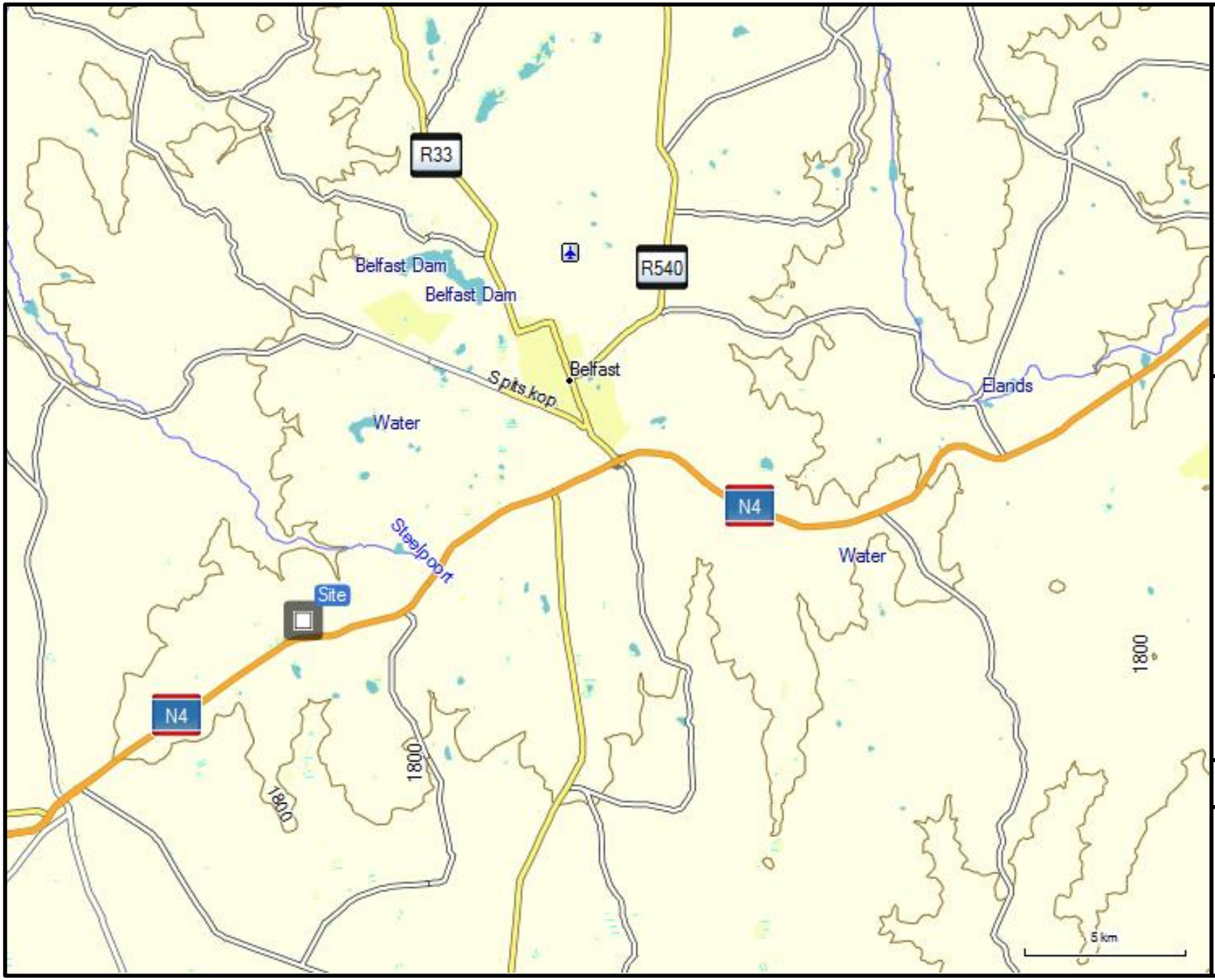
APPENDIX A

LOCALITY MAPS SHOWING GEOLOGY, GEOPHYSICAL LINES & BOREHOLE LOCATIONS



Project Title:

EXXARO BELFAST RELOCATION PROJECT: GROUNDWATER EXPLORATION

Map Title:

Site Locality Map

Map Number:

Map 1

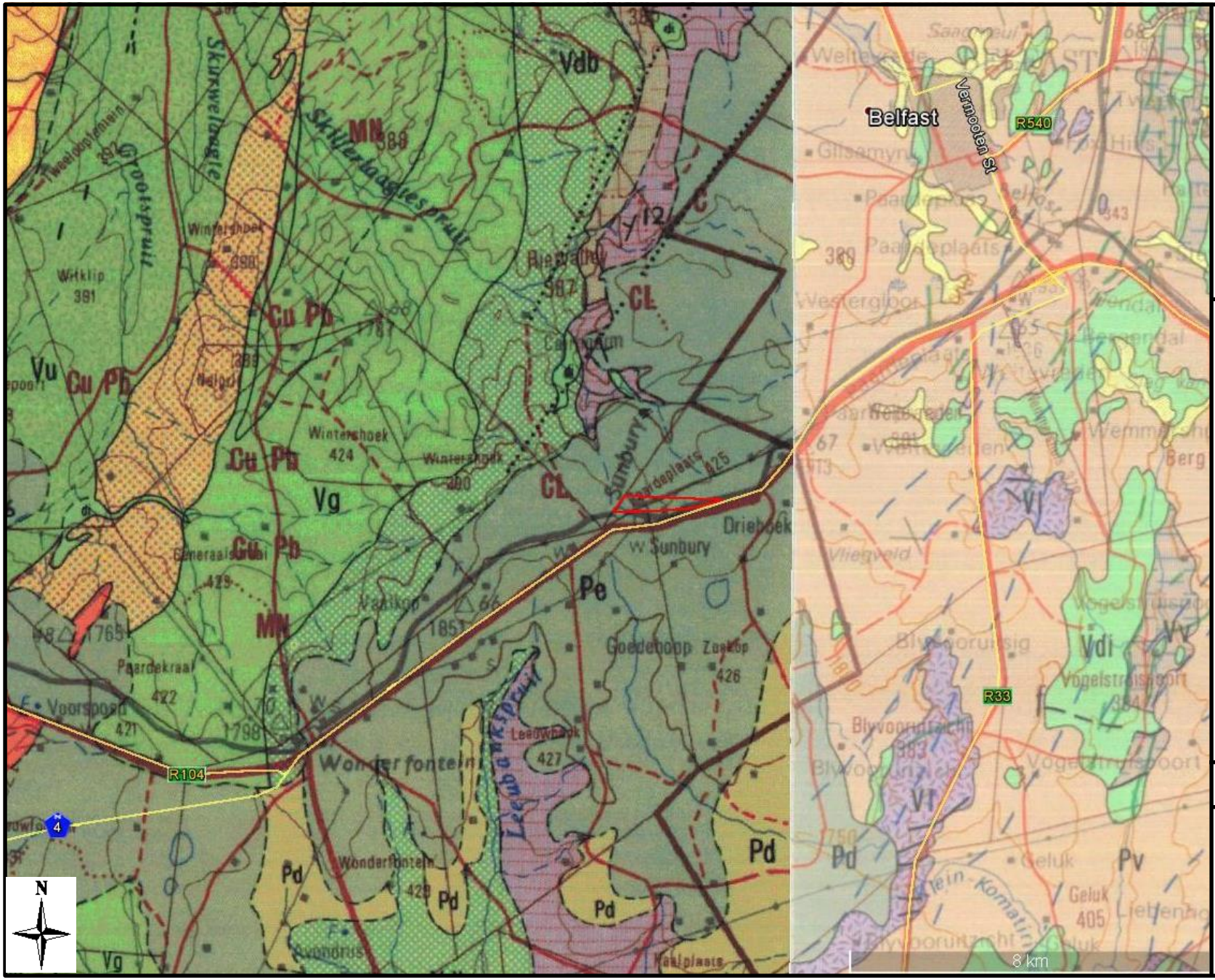
LEGEND

Proposed Relocation Site

N

Project nr: 112407

aurecon
Lynnwood Bridge Office Park
4 Daventry Street
Lynwood Manor 0040
www.aurecongroup.com



Project Title:

EXXARO BELFAST RELOCATION PROJECT: GROUNDWATER EXPLORATION

Map Title:

Geology Map

Map Number:

Map 2

LEGEND

Relocation Site

Pe/Pv: Vryheid Formation (Sandstone, Shale, Coal)

Pd: Dwyka Formation (Tillite, Shale)

Vdi: Diabse (Transvaal Supergroup)

Vg: Main Zone, Rustenburg Layered Suite (Gabbro, Norite))

Vsq/Vl: Steenkampsberg Formation (Quartzite)

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Map Title:

Geophysical Traverses

Map Number:

Map 3

LEGEND

Site Boundary

Geophysical Traverse

N

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Map Title:

Borehole Locality Map

Map Number:

Map 4

LEGEND

- Production Boreholes
- Monitoring Boreholes

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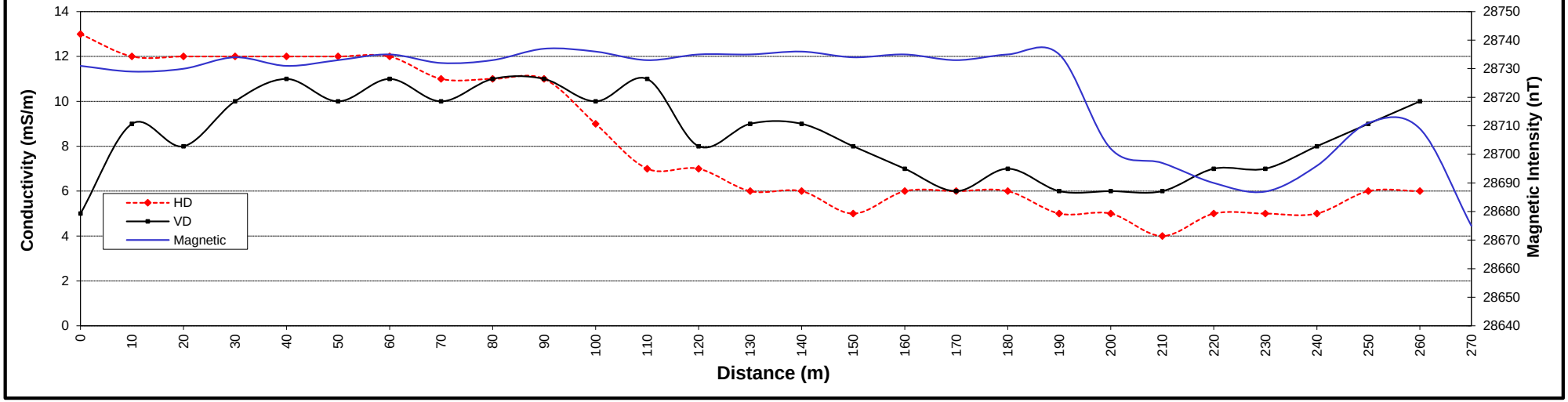
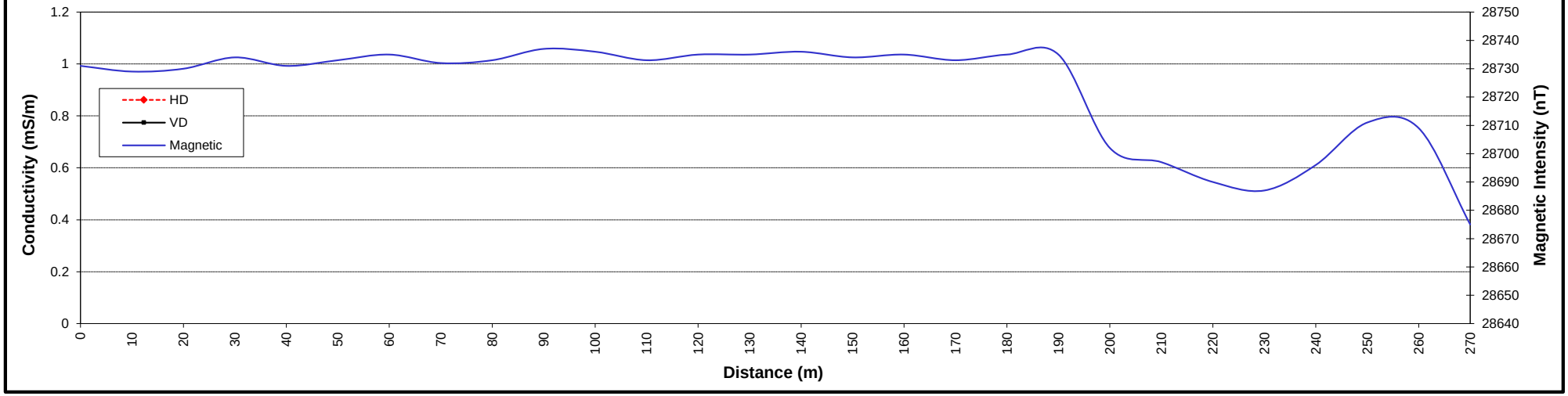
APPENDIX B

GROUND GEOPHYSICAL PROFILES

EM-34 (L=20m) & MAGNETIC PROFILE

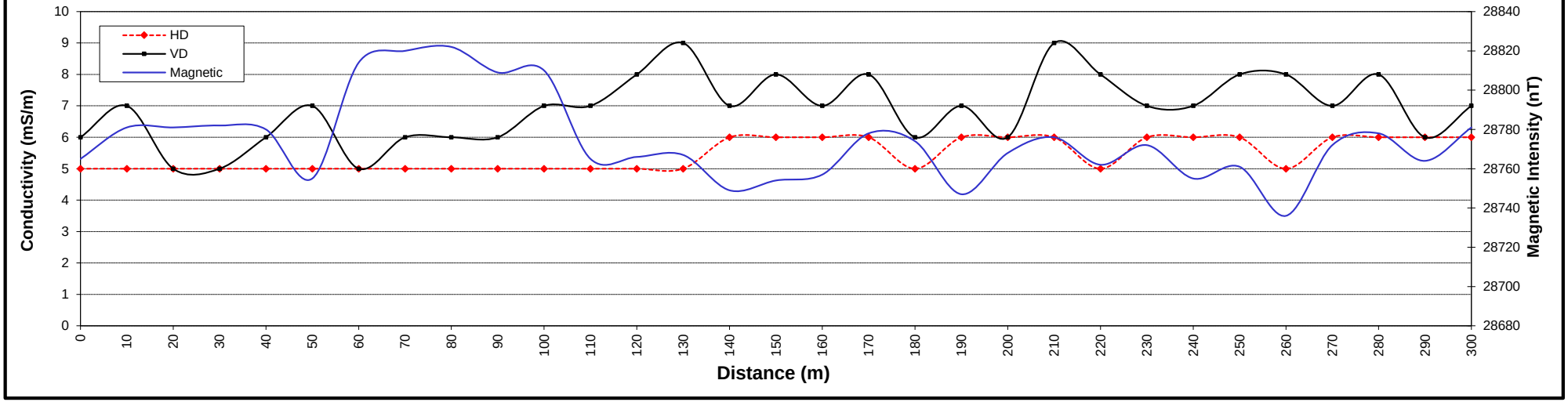


EM-34 (L=40m) & MAGNETIC PROFILE

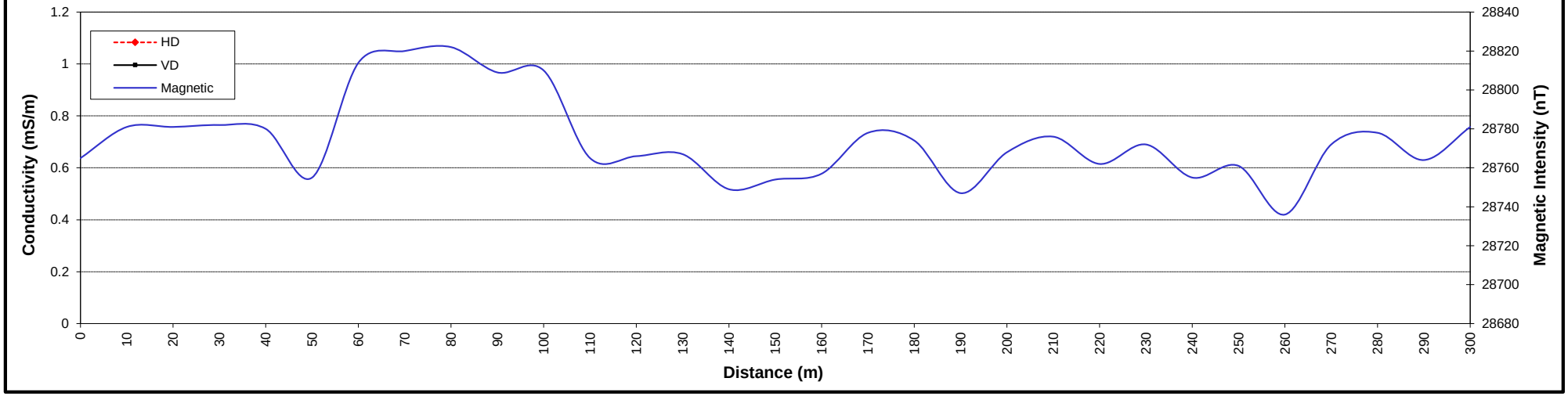


Project:	Belfast	**Profile Number:**	A-A'	**Start Coordinate:**	**S**	25.76082 °
Project Number:	112407	**Profile Direction:**	SE-NW	***(WGS84)***	**E**	29.97277 °
Survey Area:	Paardeplaats	**Station Spacing:**	10m	**End Coordinate:**	**S**	25.75918 °
Date of Survey:	9/02/2016	**Coil Spacing:**	20 & 40m		**E**	29.97494 °

EM-34 (L=20m) & MAGNETIC PROFILE



EM-34 (L=40m) & MAGNETIC PROFILE



Project:	Belfast	**Profile Number:**	B'-B	**Start Coordinate:**	**S**	25.75723
Project Number:	112407	**Profile Direction:**	NE-SW	***(WGS84)***	**E**	29.97228
Survey Area:	Paardeplaats	**Station Spacing:**	10m	**End Coordinate:**	**S**	25.75857
Date of Survey:	9/02/2016	**Coil Spacing:**	20m		**E**	29.96996

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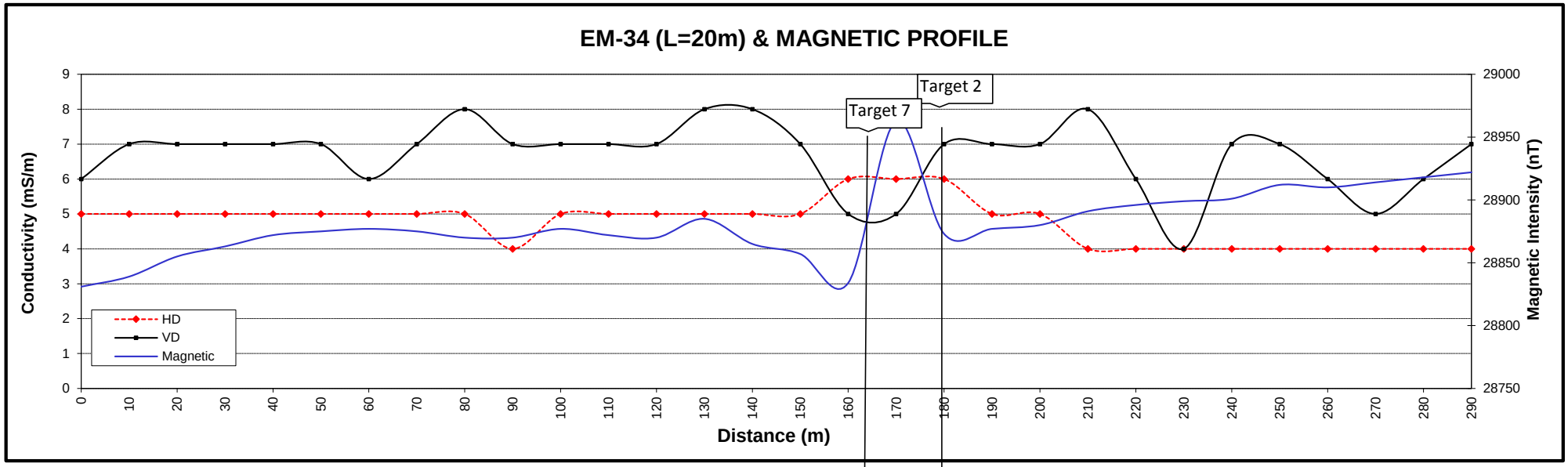
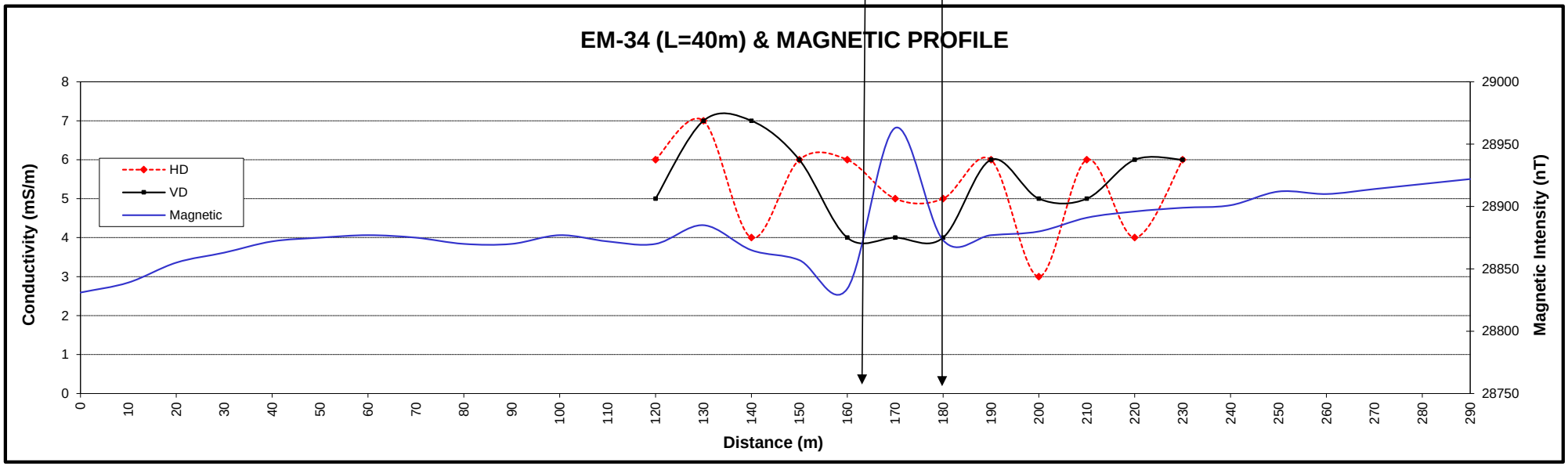
EM-34 (L=20m) & MAGNETIC PROFILE



EM-34 (L=40m) & MAGNETIC PROFILE



Project:	Belfast	**Profile Number:**	C-C'	**Start Coordinate:**	**S**	25.76044 °
Project Number:	112407	**Profile Direction:**	SE-NW	***(WGS84)***	**E**	29.96668 °
Survey Area:	Paardeplaats	**Station Spacing:**	10m	**End Coordinate:**	**S**	25.75881 °
Date of Survey:	9/02/2016	**Coil Spacing:**	20 & 40m		**E**	29.96443 °

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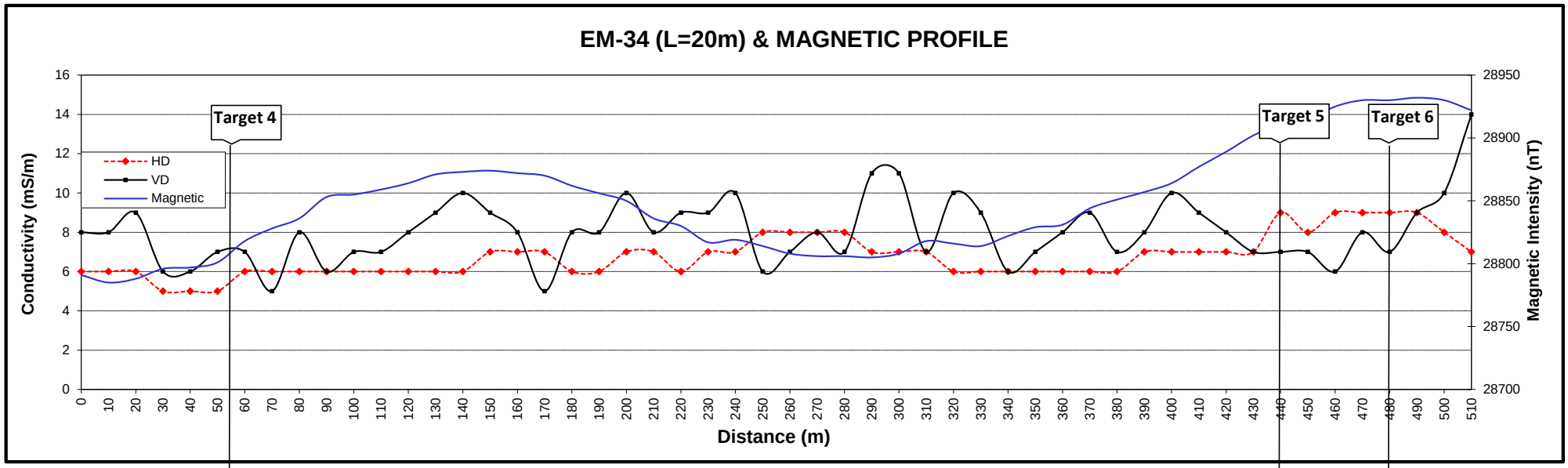
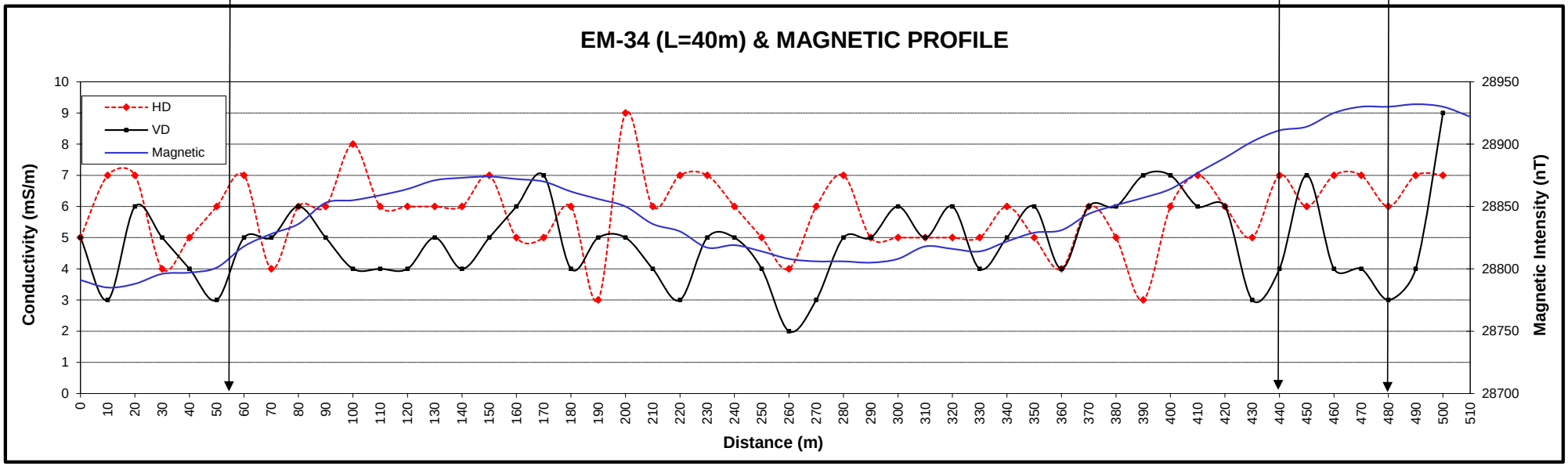
EM-34 (L=20m) & MAGNETIC PROFILE



EM-34 (L=40m) & MAGNETIC PROFILE



Project:	Belfast	**Profile Number:**	D'-I'	**Start Coordinate:**	**S**	25.75913
Project Number:	112407	**Profile Direction:**	SE-NW	***(WGS84)***	**E**	29.96919
Survey Area:	Paardeplaats	**Station Spacing:**	10m	**End Coordinate:**	**S**	25.75607
Date of Survey:	9/02/2016	**Coil Spacing:**	20 & 40m		**E**	29.96599

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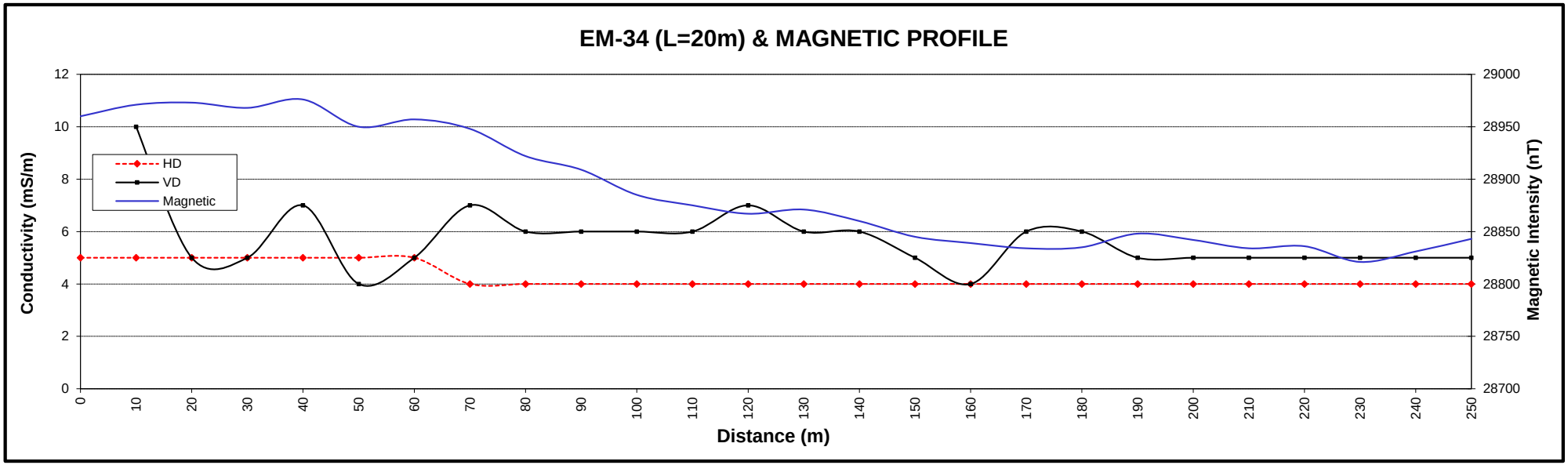
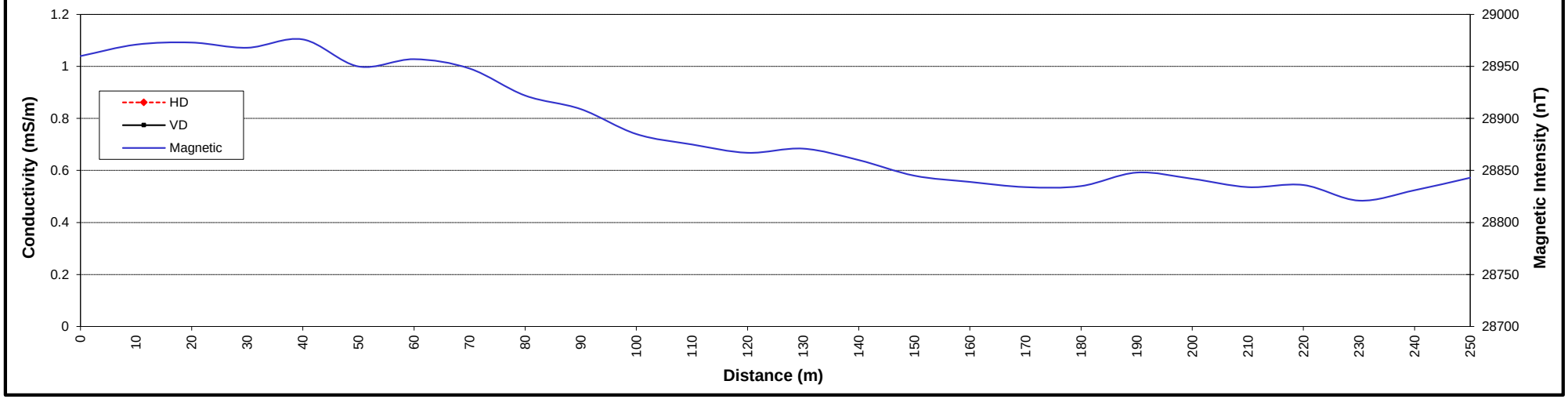
EM-34 (L=20m) & MAGNETIC PROFILE



EM-34 (L=40m) & MAGNETIC PROFILE



Project:	Belfast	**Profile Number:**	G-G'	**Start Coordinate:**	**S**	25.75949 °
Project Number:	112407	**Profile Direction:**	NNW-SSE	***(WGS84)***	**E**	29.96326 °
Survey Area:	Paardeplaats	**Station Spacing:**	10m	**End Coordinate:**	**S**	25.76146 °
Date of Survey:	9/02/2016	**Coil Spacing:**	20m		**E**	29.96398 °

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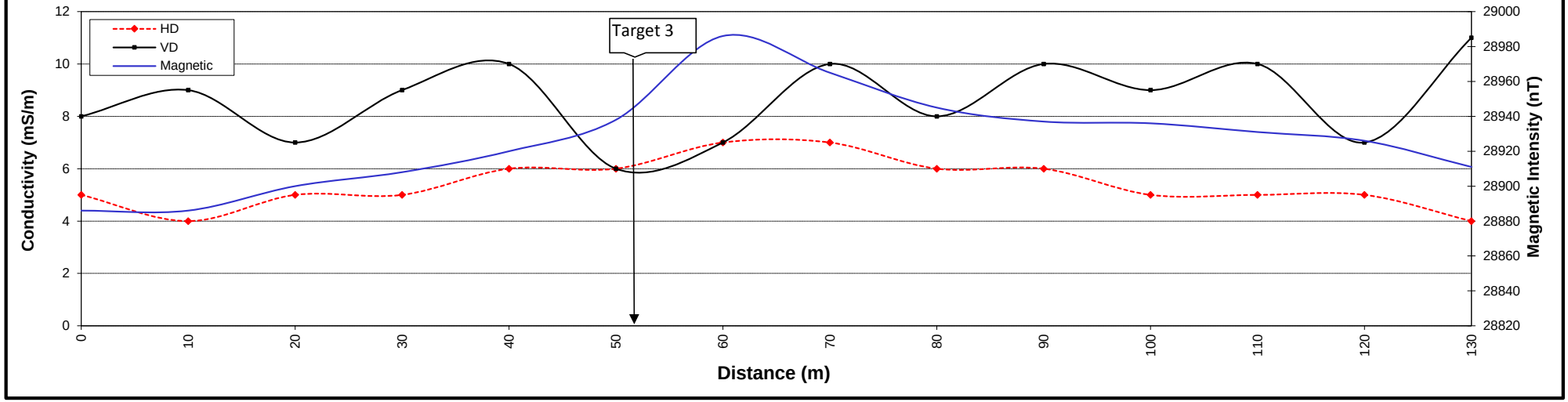
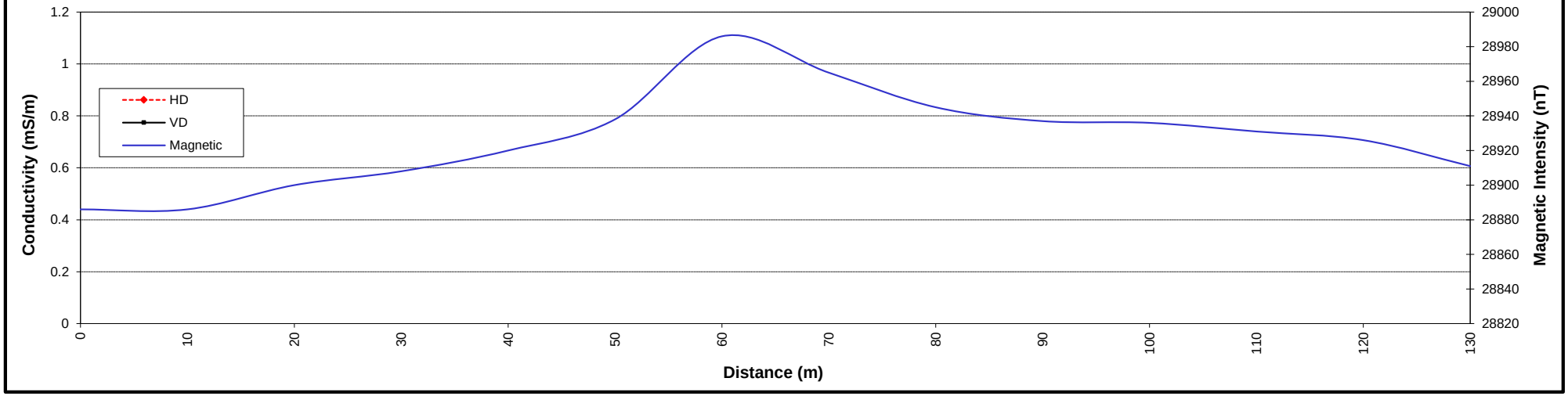
EM-34 (L=20m) & MAGNETIC PROFILE



EM-34 (L=40m) & MAGNETIC PROFILE



Project:	Belfast	**Profile Number:**	H-H'	**Start Coordinate:**	**S**	25.75850 °
Project Number:	112407	**Profile Direction:**	SE-NW	***(WGS84)***	**E**	29.96541 °
Survey Area:	Paardeplaats	**Station Spacing:**	10m	**End Coordinate:**	**S**	25.75803 °
Date of Survey:	9/02/2016	**Coil Spacing:**	20m		**E**	29.96471 °

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APPENDIX C

BOREHOLE LOGS

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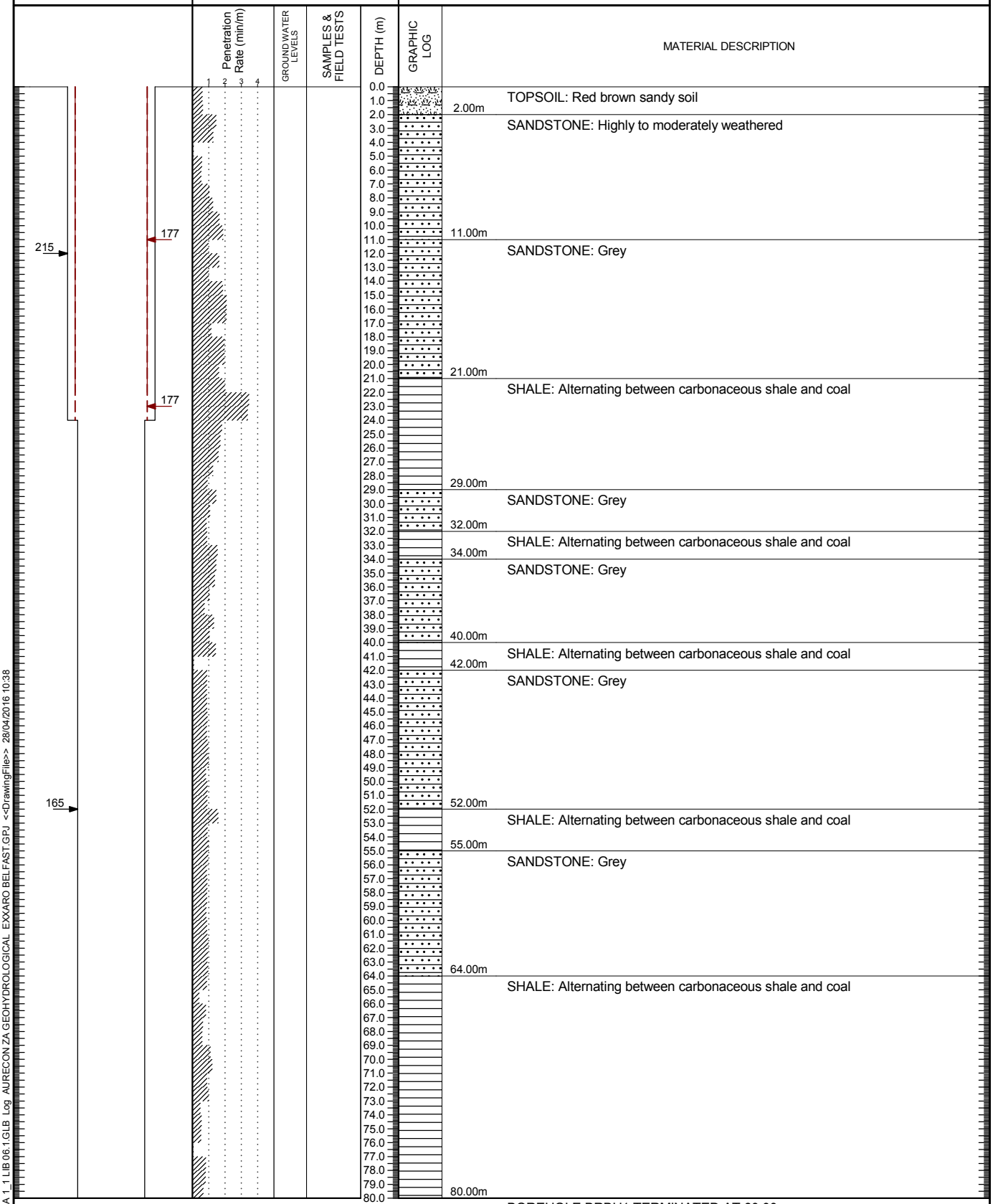
PROJECT : Exxaro Belfast Relocation Project
LOCATION : Belfast, Mpumalanga
CLIENT : Exxaro

HOLE NO : BRBH1
FILE / JOB NO : 112407
SHEET : 1 OF 1

CONTRACTOR : EDRS	RIG TYPE : Superrock	ANGLE FROM HORIZONTAL : 90°	LATITUDE : 25.76156°
DRILLER : J Oosthuyze	LOGGED BY : MT	HOLE DIA : 165 mm	LONGITUDE : 29.96534°
DATE STARTED : 16/03/14	DATE LOGGED : 16/03/15	HOLE DEPTH : 80 m	ELEVATION :
DATE COMPLETED : 16/03/15	CHECKED BY : LS	COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84

CONSTRUCTION | DRILLING | MATERIAL



Hole
Casing (plain / perforated)
Hole diameter (mm)
Casing diamater (mm)

AURECON AGS 3_1 RTA 1_1 LIB 06.1.GLB Log AURECON ZA GEOHYDROLOGICAL EXXARO BELFAST.GPJ <<DrawingFile>> 28/04/2016 10:38

aurecon

PROJECT : **Exxaro Belfast Relocation Project**
LOCATION : Belfast, Mpumalanga
CLIENT : Exxaro

HOLE NO : BRBH2
FILE / JOB NO : 112407
SHEET : 1 OF 1

CONTRACTOR : EDRS	RIG TYPE : Superrock	ANGLE FROM HORIZONTAL : 90°	LATITUDE : 25.75937°
DRILLER : J Oosthuyze	LOGGED BY : MT	HOLE DIA : 165 mm	LONGITUDE : 29.96526°
DATE STARTED : 16/03/15	DATE LOGGED : 16/03/15	HOLE DEPTH : 80 m	ELEVATION :
DATE COMPLETED : 16/03/25	CHECKED BY : LS	COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84

CONSTRUCTION | DRILLING | MATERIAL

Penetration Rate (min/m) 1 2 3 4

GROUNDWATER LEVELS: 02/04/16

SAMPLES & FIELD TESTS

DEPTH (m) / GRAPHIC LOG

Depth (m)	MATERIAL DESCRIPTION
0.0	
1.00m	TOPSOIL: Sand and ferricrete
	SAND: Clayey sand, cream
11.00m	
12.00m	SHALE: Grey
	SANDSTONE: Grey
17.00m	
18.00m	SHALE: Brown
19.00m	SANDSTONE: Grey
	SANDSTONE: Brown, weathered
24.00m	
	SANDSTONE: Grey
27.00m	
28.00m	COAL: Coal
	SANDSTONE: Grey
41.00m	
	SANDSTONE: White
52.00m	
	SANDSTONE: Dark grey
68.00m	
70.00m	COAL: Coal
	SANDSTONE: Dark grey
77.00m	
78.00m	COAL: Coal
80.00m	SANDSTONE: Dark grey
	BOREHOLE BRBH2 TERMINATED AT 80.00 m

177
215
177
165

Hole
Casing (plain / perforated)
Hole diameter (mm)
Casing diamater (mm)

AURECON AGS 3_1 RTA 1_1 LIB 06.1.GLB Log AURECON ZA GEOHYDROLOGICAL EXXARO BELFAST.GPJ <<DrawingFile>> 28/04/2016 10:38

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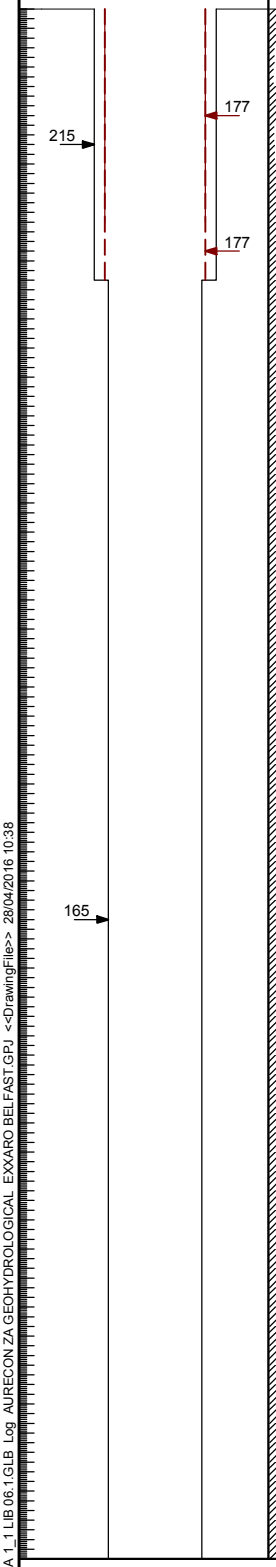
PROJECT : Exxaro Belfast Relocation Project
LOCATION : Belfast, Mpumalanga
CLIENT : Exxaro

HOLE NO : BRBH3
FILE / JOB NO : 112407
SHEET : 1 OF 1

CONTRACTOR : EDRS	RIG TYPE : Superrock	ANGLE FROM HORIZONTAL : 90°	LATITUDE : 25.75619°
DRILLER : J Oosthuyze	LOGGED BY : MT	HOLE DIA : 165 mm	LONGITUDE : 29.96611°
DATE STARTED : 16/03/15	DATE LOGGED : 16/03/16	HOLE DEPTH : 80 m	ELEVATION :
DATE COMPLETED : 16/03/16	CHECKED BY : LS	COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84

CONSTRUCTION | DRILLING | MATERIAL



Penetration Rate (min/m) 1 2 3 4 | GROUNDWATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG

Depth (m)	MATERIAL DESCRIPTION
0.0	TOPSOIL: Red sandy soil
3.00m	SANDSTONE: Highly weathered, cream
8.00m	SANDSTONE: Slightly weathered, grey
36.00m	SANDSTONE: Slightly weathered, light grey
42.00m	SHALE: Carbonasceous
44.00m	SANDSTONE: Grey
56.00m	SANDSTONE: Dark grey
58.00m	SHALE: Dark grey
62.00m	COAL: Coal
64.00m	SANDSTONE: Grey
66.00m	SHALE: Carbonaceous, coal in places
68.00m	SANDSTONE: Grey
70.00m	SANDSTONE: Light Grey
80.00m	BOREHOLE BRBH3 TERMINATED AT 80.00 m

Hole
Casing (plain / perforated)
Hole diameter (mm)
Casing diamater (mm)

AURECON AGS 3_1 RTA 1_1 LIB 06.1.GLB Log AURECON ZA GEOHYDROLOGICAL EXXARO BELFAST.GPJ <<DrawingFile>> 28/04/2016 10:38

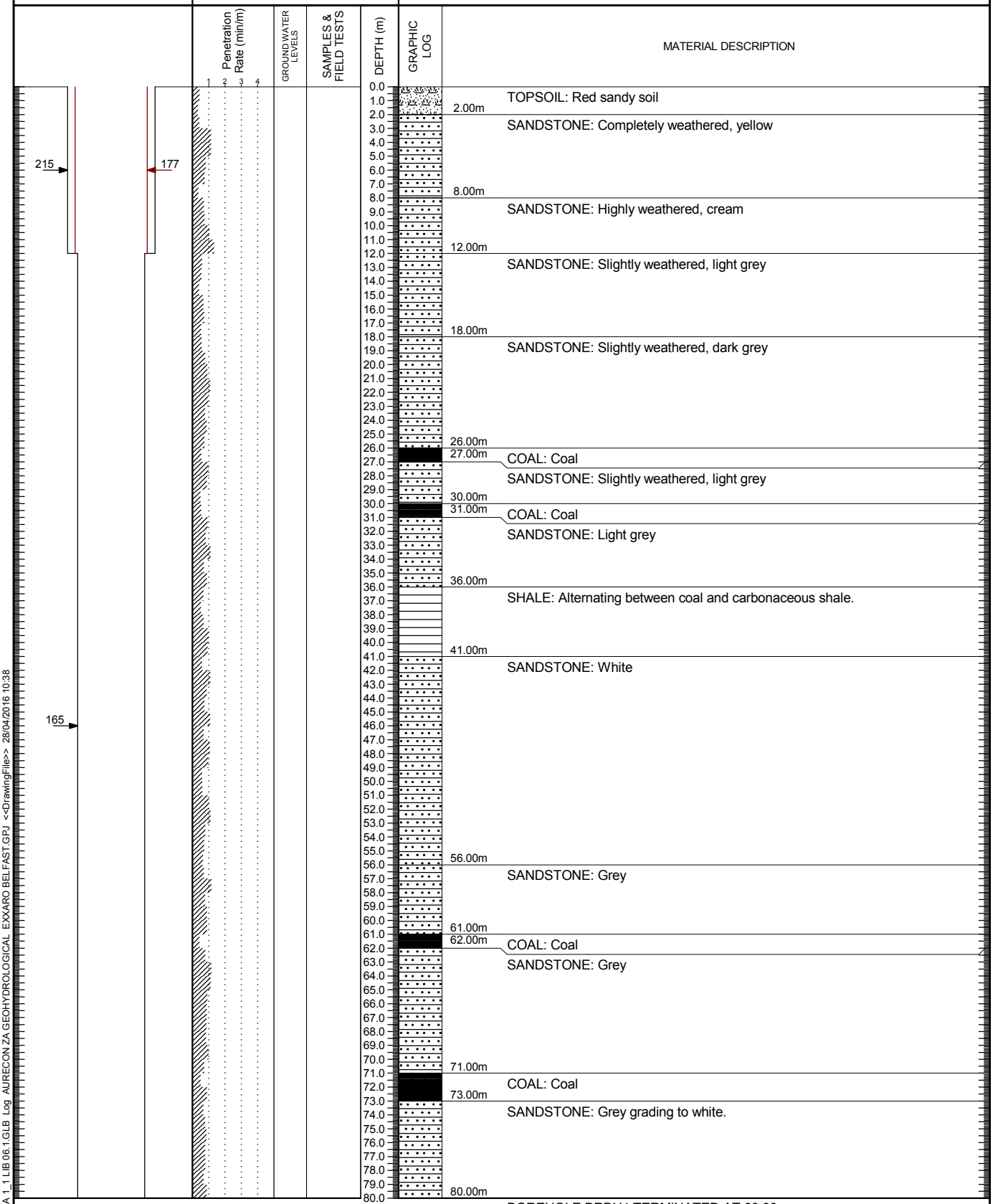
aurecon

PROJECT : Exxaro Belfast Relocation Project
LOCATION : Belfast, Mpumalanga
CLIENT : Exxaro

HOLE NO : BRBH4
FILE / JOB NO : 112407
SHEET : 1 OF 1

CONTRACTOR : EDRS	RIG TYPE : Superrock	ANGLE FROM HORIZONTAL : 90°	LATITUDE : 25.75947°
DRILLER : J Oosthuyze	LOGGED BY : MT	HOLE DIA : 165 mm	LONGITUDE : 29.96539°
DATE STARTED : 16/03/16	DATE LOGGED : 16/03/16	HOLE DEPTH : 80 m	ELEVATION :
DATE COMPLETED : 16/03/16	CHECKED BY : LS	COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84

CONSTRUCTION | DRILLING | MATERIAL



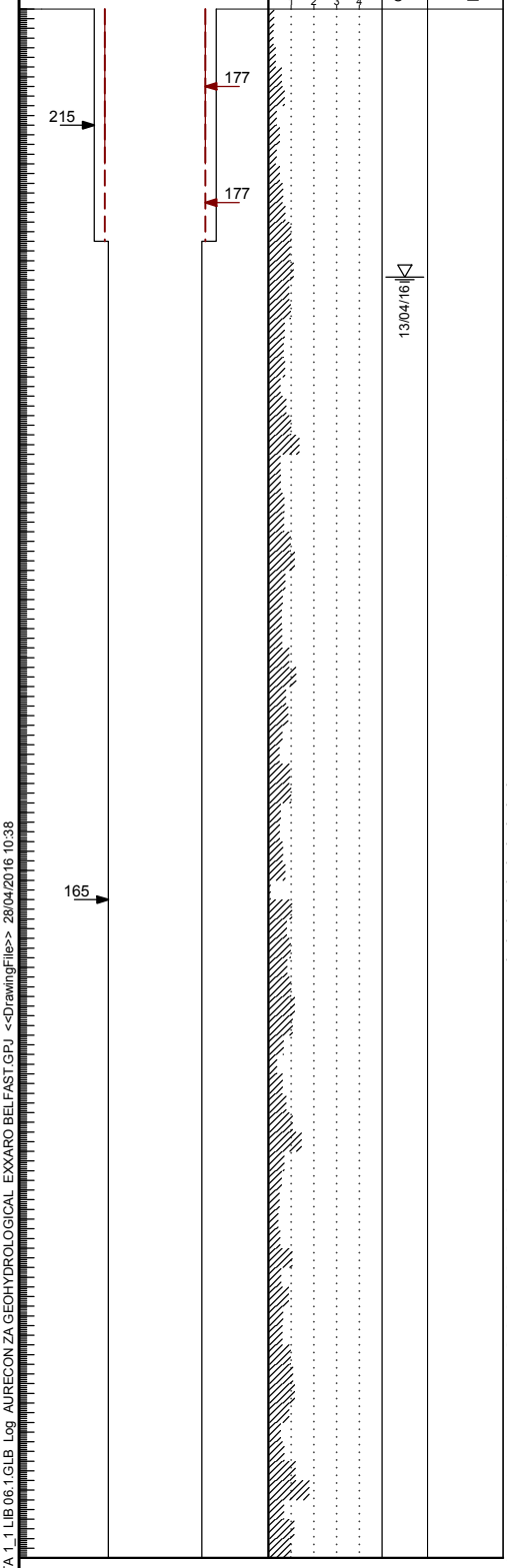
Hole
Casing (plain / perforated)
Hole diameter (mm)
Casing diamater (mm)

PROJECT : Exxaro Belfast Relocation Project
LOCATION : Belfast, Mpumalanga
CLIENT : Exxaro

HOLE NO : BRBH5
FILE / JOB NO : 112407
SHEET : 1 OF 1

CONTRACTOR : EDRS	RIG TYPE : Superrock	ANGLE FROM HORIZONTAL : 90°	LATITUDE : 25.75881°
DRILLER : J Oosthuyze	LOGGED BY : MT	HOLE DIA : 165 mm	LONGITUDE : 29.96888°
DATE STARTED : 16/03/16	DATE LOGGED : 16/03/17	HOLE DEPTH : 80 m	ELEVATION :
DATE COMPLETED : 16/03/17	CHECKED BY : LS	COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84

CONSTRUCTION | DRILLING | MATERIAL



DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0		
2.00m		TOPSOIL: Red sandy soil and Ferricrete
7.00m		SANDSTONE: Competely weathered, yellow brown
13.00m		SANDSTONE: Grey. Fractured @ 11m. 5200l/h
16.00m		SHALE: Carbonaceous and coal, alternating.
25.00m		SANDSTONE: Light grey
30.00m		SHALE: Carbonaceous and coal, alternating.
51.00m		SANDSTONE: Light grey
58.00m		SANDSTONE: Dark grey
64.00m		COAL: Coal
66.00m		SHALE: Carbonaceous
68.00m		SANDSTONE: Dark Grey
71.00m		CARBONACEOUS: Fracture @ 71m, 1800l/h
80.00m		SANDSTONE: Grey
		BOREHOLE BRBH5 TERMINATED AT 80.00 m

Hole
Casing (plain / perforated)
Hole diameter (mm)
Casing diamater (mm)

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PROJECT : Exxaro Belfast Relocation Project
LOCATION : Belfast, Mpumalanga
CLIENT : Exxaro

HOLE NO : BRBH6
FILE / JOB NO : 112407
SHEET : 1 OF 1

CONTRACTOR : EDRS | RIG TYPE : Superrock | ANGLE FROM HORIZONTAL : 90° | LATITUDE : 25.75829°
DRILLER : J Oosthuyze | LOGGED BY : MT | HOLE DIA : 165 mm | LONGITUDE : 29.96506°
DATE STARTED : 16/03/17 | DATE LOGGED : 16/03/17 | HOLE DEPTH : 80 m | ELEVATION :
DATE COMPLETED : 16/03/17 | CHECKED BY : LS | COLLAR HEIGHT : 0.5 m | GRID & DATUM : WGS84

CONSTRUCTION | DRILLING | MATERIAL

Penetration Rate (min/m) 1 2 3 4 | GROUNDWATER LEVELS | SAMPLES & FIELD TESTS | DEPTH (m) | GRAPHIC LOG | MATERIAL DESCRIPTION

215 165 165

08/04/16

Depth (m)	Material description
0.0	
1.00m	TOPSOIL: Red sandy soil and ferricrete
	SANDSTONE: Completely weathered, yellow brown
8.00m	
	SANDSTONE: Moderately weathered, yellow brown
14.00m	
	SANDSTONE: Grey. Waterstrike @ 21m, 4680l/h.
21.00m	
	SHALE: Carbonaceous and coal, alternating.
27.00m	
	SANDSTONE: Grey
33.00m	
	SHALE: Carbonaceous and coal, alternating.
38.00m	
	SANDSTONE: Light grey
55.00m	
	SANDSTONE: Dark grey
63.00m	
	SHALE: Carbonaceous and coal, alternating.
78.00m	
80.00m	SANDSTONE: Grey
	BOREHOLE BRBH6 TERMINATED AT 80.00 m

Hole
Casing (plain / perforated)
Hole diameter (mm)
Casing diamater (mm)

AURECON AGS 3_1 RTA 1_1 LIB 06.1.GLB Log AURECON ZA GEOHYDROLOGICAL EXXARO BELFAST.GPJ <<DrawingFile>> 28/04/2016 10:38

APPENDIX D

CALCULATION OF SUSTAINABLE YIELD (FC – SOLUTIONS)

FC-METHOD : Estimation of the sustainable yield of a borehole

BRBH2

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	40.46	40.46	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.25	4.05E-04	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	10.2	0.2	Sigma_s from risk	
Annual effective recharge (mm) =	15	25.20	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	2880	2.74	End time and drawdown of test	
Average maximum derivative = (enter)	3.7	3.7	Estimate of average of max deriv	
Average second derivative = (enter)	0.0	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	0.46	0.46	Read from derivative graph	
	T-early[m^2/d] =	8.66	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	1.08	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	1.10E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)
(No values of T and S are necessary)

	No boundaries	Maximum influence of boundaries at long time: 1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	12.02	21.39	30.77	58.90
Q_sust (l/s) =	0.52	0.29	0.20	0.11
	Best case	→		**Worst case**

Average Q_sust (l/s) = 0.24
with standard deviation= 0.18

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)
(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) →	1.08			
S-late = (enter) →	1.00E-03			
1. BOUNDARY INFORMATION (choose a or b)		(Code =9999 = dummy value if not applicable)		
(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	1000	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.23	0.00	#NUM!
(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	#NUM!
2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	5.19E-04	6.99

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	0.20	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →	0.20	Sigma_s =	1.396	

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.25
Total amount of water allowed to be abstracted per month (m^3) =	648

COMMENTS

Q_sust with 68% safety =
Q_sust with 95% safety =

FC-METHOD : Estimation of the sustainable yield of a borehole

BRBH5

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	52.85	52.85	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1.6	7.39E-05	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	56.8	0.34	Sigma_s from risk	
Annual effective recharge (mm) =	15	71.83	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1560	47.86	End time and drawdown of test	
Average maximum derivative = (enter)	78.3	78.3	Estimate of average of max deriv	
Average second derivative = (enter)	0.1	0.1	Estimate of average second deriv	
Derivative at radial flow period = (enter)	1.91	1.91	Read from derivative graph	
	T-early[m^2/d] =	13.24	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	0.32	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	1.10E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)
(No values of T and S are necessary)

	No boundaries	Maximum influence of boundaries at long time: 1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	269.86	491.32	712.78	1377.18
Q_sust (l/s) =	0.43	0.23	0.16	0.08
	Best case →			**Worst case**

Average Q_sust (l/s) = 0.19
with standard deviation= 0.15

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)
(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) →	0.32			
S-late = (enter) →	1.00E-03			
1. BOUNDARY INFORMATION (choose a or b)		(Code =9999 = dummy value if not applicable)		
(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	1000	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	#NUM!	0.10	#NUM!	#NUM!
(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	#NUM!	0.00	#NUM!	#NUM!
2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	2.96E-03	5.25

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	0.33	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →	0.34	Sigma_s =	6.003	

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.50
Total amount of water allowed to be abstracted per month (m^3) =	1296

COMMENTS

Q_sust with 68% safety =
Q_sust with 95% safety =

FC-METHOD : Estimation of the sustainable yield of a borehole

BRBH6

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	43.89	43.89	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1.55	3.00E-06	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	5.3	1.32	Sigma_s from risk	
Annual effective recharge (mm) =	0	5.30	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	2880	4.47	End time and drawdown of test	
Average maximum derivative = (enter)	0.6	0.6	Estimate of average of max deriv	
Average second derivative = (enter)	-0.2	-0.2	Estimate of average second deriv	
Derivative at radial flow period = (enter)	1.07	1.07	Read from derivative graph	
	T-early[m^2/d] =	22.91	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	43.67	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	1.10E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)
(No values of T and S are necessary)

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
		Maximum influence of boundaries at long time		
sWell (Extrapol.time) =	5.12	6.56	8.00	12.31
Q_sust (l/s) =	1.60	1.25	1.03	0.67
	Best case	→		**Worst case**

Average Q_sust (l/s) = 1.08
with standard deviation= 0.39

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)
(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) → 43.67
S-late = (enter) → 1.00E-03

1. BOUNDARY INFORMATION (choose a or b) (Code =9999 = dummy value if not applicable)

(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	1000	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.01	0.71	0.01	0.01
(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	-0.01	0.00	0.00	0.00

2. INFLUENCE OF OTHER BOREHOLES →

	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	1.51E-05	10.52

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	1.06	9999.00	9999.00

Enter selected Q for risk analysis = (enter) → 1.32 Sigma_s = 0.396

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	1.00
Total amount of water allowed to be abstracted per month (m^3) =	2592

COMMENTS

Q_sust with 68% safety =
Q_sust with 95% safety =

APPENDIX E

LABORATORY REPORTS

aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report

Client: Aurecon
Address: Lynwood Bridge Office Park, No. 4 Daventry str., Pretoria, 0081
Report no: 30228
Project: Aurecon

Date of certificate: 12 April 2016
Date accepted: 05 April 2016
Date completed: 12 April 2016
Revision: 0

Lab no:				253348
Date sampled:				05-Apr-16
Sample type:				Water
Locality description:				BRBH2
	Analyses	**Unit**	**Method**	
A	pH @ 25°C	pH	ALM 20	8.23
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	20.2
A	Total dissolved solids (TDS)	mg/l	ALM 26	131
A	Total alkalinity	mg $CaCO_3$/l	ALM 01	75.8
A	Chloride (Cl)	mg/l	ALM 02	4.78
A	Sulphate (SO_4)	mg/l	ALM 03	31.3
A	Nitrate (NO_3) as N	mg/l	ALM 06	0.368
A	Ammonium (NH_4) as N	mg/l	ALM 05	0.093
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.035
A	Fluoride (F)	mg/l	ALM 08	<0.142
A	Calcium (Ca)	mg/l	ALM 30	23.5
A	Magnesium (Mg)	mg/l	ALM 30	8.20
A	Sodium (Na)	mg/l	ALM 30	9.28
A	Potassium (K)	mg/l	ALM 30	5.39
A	Aluminium (Al)	mg/l	ALM 31	<0.002
A	Iron (Fe)	mg/l	ALM 31	2.43
A	Manganese (Mn)	mg/l	ALM 31	0.021
A	E.coli	CFU/100ml	ALM 40	<1
N	Faecal coliform	CFU/100ml	ALM 42	<1
A	Total coliform	CFU/100ml	ALM 40	<1
A	Total hardness	mg $CaCO_3$/l	ALM 26	92

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine
The results relates only to the test item tested.
Results reported against the limit of detection.
Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory.
Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.

H. Holtzhausen
Director Laboratory Services

aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report

Client: Aurecon
Address: Lynwood Bridge Office Park, No. 4 Daventry str., Pretoria, 0081
Report no: 30343
Project: Aurecon

Date of certificate: 15 April 2016
Date accepted: 11 April 2016
Date completed: 15 April 2016
Revision: 0

Lab no:				254252
Date sampled:				11-Apr-16
Sample type:				Water
Locality description:				BRBH6
	Analyses	**Unit**	**Method**	
A	pH @ 25°C	pH	ALM 20	8.25
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	16.9
A	Total dissolved solids (TDS)	mg/l	ALM 26	88
A	Total alkalinity	mg $CaCO_3$/l	ALM 01	81.1
A	Chloride (Cl)	mg/l	ALM 02	1.18
A	Sulphate (SO_4)	mg/l	ALM 03	4.16
A	Nitrate (NO_3) as N	mg/l	ALM 06	0.288
A	Ammonium (NH_4) as N	mg/l	ALM 05	0.066
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.096
A	Fluoride (F)	mg/l	ALM 08	0.160
A	Calcium (Ca)	mg/l	ALM 30	14.7
A	Magnesium (Mg)	mg/l	ALM 30	5.41
A	Sodium (Na)	mg/l	ALM 30	7.47
A	Potassium (K)	mg/l	ALM 30	4.19
A	Aluminium (Al)	mg/l	ALM 31	<0.002
A	Iron (Fe)	mg/l	ALM 31	<0.004
A	Manganese (Mn)	mg/l	ALM 31	<0.001
A	E.coli	CFU/100ml	ALM 40	<1
N	Faecal coliform	CFU/100ml	ALM 42	<1
A	Total coliform	CFU/100ml	ALM 40	4
A	Total hardness	mg $CaCO_3$/l	ALM 26	59

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine
The results relates only to the test item tested.
Results reported against the limit of detection.
Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory.
Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.

H. Holtzhausen
Director Laboratory Services

aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report

Client: Aurecon
Address: Lynwood Bridge Office Park, No. 4 Daventry str., Pretoria, 0081
Report no: 30480
Project: Aurecon

Date of certificate: 21 April 2016
Date accepted: 15 April 2016
Date completed: 21 April 2016
Revision: 0

Lab no:				255208
Date sampled:				15-Apr-16
Sample type:				Water
Locality description:				BRBH5
	Analyses	**Unit**	**Method**	
A	pH @ 25°C	pH	ALM 20	8.06
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	18.1
A	Total dissolved solids (TDS)	mg/l	ALM 26	106
A	Total alkalinity	mg $CaCO_3$/l	ALM 01	94.7
A	Chloride (Cl)	mg/l	ALM 02	2.71
A	Sulphate (SO_4)	mg/l	ALM 03	5.66
A	Nitrate (NO_3) as N	mg/l	ALM 06	0.237
A	Ammonium (NH_4) as N	mg/l	ALM 05	0.011
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.063
A	Fluoride (F)	mg/l	ALM 08	0.268
A	Calcium (Ca)	mg/l	ALM 30	19.9
A	Magnesium (Mg)	mg/l	ALM 30	6.10
A	Sodium (Na)	mg/l	ALM 30	8.60
A	Potassium (K)	mg/l	ALM 30	4.40
A	Aluminium (Al)	mg/l	ALM 31	<0.002
A	Iron (Fe)	mg/l	ALM 31	<0.004
A	Manganese (Mn)	mg/l	ALM 31	<0.001
A	E.coli	CFU/100ml	ALM 40	<1
N	Faecal coliform	CFU/100ml	ALM 42	<1
A	Total coliform	CFU/100ml	ALM 40	<1
A	Total hardness	mg $CaCO_3$/l	ALM 26	75

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine
The results relates only to the test item tested.
Results reported against the limit of detection.
Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory.
Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.

H. Holtzhausen
Director Laboratory Services

APPENDIX F

PUMPTESTING FIELD SHEETS

Telephone: 043-732 1211
Fax no: 043-732 1422
Fax to e-mail: 0866 717 732
E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PR0JECT #	P1582
BBR	CHRISTOPHER
PRODUCTION BONUS:	SAMUEL
EC meter number	UNMARKED BLUE

CONSULTANT: SRK EL
DISTRICT: BELFAST
PROVINCE: MPUMALANGA
FARM / VILLAGE NAME : BELFAST
DATE TESTED: 02/04/2016

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS:	hddd ° mm ' ss.s "		hddd ° mm.mmm '		hddd.ddddd °
LATITUDE:	° ' "	OR	° '	OR	25.75940 °
LONGITUDE:	° ' "		° '		29.96537 °

BOREHOLE NO: BR BH 2
TRANSMISSIVITY VALUE:
TYPE INSTALLATION: NEW BOREHOLE
BOREHOLE DEPTH: (mbgl) 79.25

COMMENTS: THE WATER WAS FINISHED IN 90MINS SO WE STARTED ON LOWER YEILD WHICH WAS 0.25L/S

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	DATA CAPTURED BY:	AVN
Date sample taken			If consultant took sample, give name:			DATA CHECKED BY:	AVN
Time sample taken							

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:	0.50	l/s	WATER STRIKE 1:			m
BLOW YIELD:		m	STEP 2:	1.00	l/s	WATER STRIKE 2:			m
STATIC WATER LEVEL:		m	STEP 3:	2.00	l/s	WATER STRIKE 3:			m
PUMP INSTALLATION DEPTH:		m	STEP 4:	4.00	l/s	**COMMENTS:**			
RECOVERY:			STEP 5:		l/s				
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)			
AFTER CONSTANT:		h	STEP DURATION:		min				

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	63.18
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	7.98
CASING DETECTION:	NO	1	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	0	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	50
LOGGERS FOR WATERLEVEL MONITORING	NO	2	LOGGERS FOR pH AND EC:	NO	0

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

NAME: _____ **SIGNATURE:** _____
DESIGNATION: _____ **DATE:** _____

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1582	MAP REFERENCE:	0	PROVINCE:	MPUMALANGA
BOREHOLE NO:	BR BH 2			DISTRICT:	BELFAST
ALT BH NO:	0			SITE NAME:	BELFAST
ALT BH NO:	0				

BOREHOLE DEPTH (m)	79.25	DATUM LEVEL ABOVE CASING (m):	0.47	EXISTING PUMP:	0
WATER LEVEL (mbdl):	8.44	CASING HEIGHT: (magl):	0.56	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	63.18	DIAM PUMP INLET (mm):	1.65	PUMP TYPE:	DW 2402

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE:	02/04/2016	TIME:	09H30		DATE:	02/04/2016	TIME:	10H30		DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.61		**1**		**1**	3.90		**1**	51.36	**1**			**1**	
2	0.89		**2**		**2**	5.13		**2**	49.10	**2**			**2**	
3	1.13		**3**		**3**	6.00		**3**	48.92	**3**			**3**	
5	1.25	0.54	**5**		**5**	6.94	1.09	**5**	43.11	**5**			**5**	
7	1.46		**7**		**7**	7.35		**7**	42.20	**7**			**7**	
10	1.81	0.55	**10**		**10**	8.03	1.07	**10**	41.02	**10**			**10**	
15	2.14		**15**		**13**	16.60		**15**	39.67	**15**			**15**	
20	2.50	0.56	**20**		**14**	37.80	1.09	**20**	38.50	**20**			**20**	
30	2.73		**30**		**15**	44.90		**30**	37.43	**30**			**30**	
40	2.85	0.53	**40**		**20**	54.74		**40**	36.14	**40**			**40**	
50	3.05		**50**		**25**	54.74	0.51	**50**	35.03	**50**			**50**	
60	3.21	0.54	**60**		**30**	54.74	0.48	**60**	33.64	**60**			**60**	
70			**70**		**40**	54.74	0.45	**70**	31.44	**70**			**70**	
80			**80**					**80**		**80**			**80**	
90			**90**					**90**		**90**			**90**	
100			**100**					**100**		**100**			**100**	
110			**110**					**110**		**110**			**110**	
120			**120**					**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP	21.50	°C	**180**		**TEMP**	20.90	°C	**180**		**TEMP**		°C	**180**	
EC	193.00	µS/cm	**210**		**EC**	206.00	µS/cm	**210**		**EC**		µS/cm	**210**	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:		TIME:			DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			**1**		**1**			**1**		**1**			**1**	
2			**2**		**2**			**2**		**2**			**2**	
3			**3**		**3**			**3**		**3**			**3**	
5			**5**		**5**			**5**		**5**			**5**	
7			**7**		**7**			**7**		**7**			**7**	
10			**10**		**10**			**10**		**10**			**10**	
15			**15**		**15**			**15**		**15**			**15**	
20			**20**		**20**			**20**		**20**			**20**	
30			**30**		**30**			**30**		**30**			**30**	
40			**40**		**40**			**40**		**40**			**40**	
50			**50**		**50**			**50**		**50**			**50**	
60			**60**		**60**			**60**		**60**			**60**	
70			**70**		**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**		**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	
			240					**240**					**240**	
			300					**300**					**300**	
			360					**360**					**360**	

S/W/L:(mbch) 7.98

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1582	MAP REFERENCE:	25.7514	PROVINCE:	MPUMALANGA
BOREHOLE NO:	BRBH 2		29.96563	DISTRICT:	BELFAST
ALT BH NO:	0			SITE NAME:	BELFAST
ALT BH NO:	0				
BOREHOLE DEPTH:	79.25	DATUM LEVEL ABOVE CASING (m):	0.47	EXISTING PUMP:	0
WATER LEVEL (mbdl):	8.80	CASING HEIGHT: (magl):	0.50	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	0.00	DIAM PUMP INLET(mm):	165	PUMP TYPE:	0

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				**TEST COMPLETED**					
DATE:	04/04/2016	TIME:	07H33	DATE:	04/04/2016	TIME:	07H33	TYPE OF PUMP:	0

					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3	
					NR: **BRBH 2**			NR: **BRBH6**			NR:	
DISCHARGE BOREHOLE					Distance(m);		15.8	Distance(m);			Distance(m);	
TIME	DRAW	YIELD	TIME	RECOVERY	TIME:	Drawdown	Recovery	TIME:	Drawdown	Recovery	TIME:	Drawdown
(MIN)	DOWN (M)	(L/S)	MIN	(M)	(min)	m	(m)	(min)	(m)		(min)	(m)
1	0.48		**1**	2.37	**1**			**1**			**1**	
2	0.51		**2**	2.19	**2**			**2**			**2**	
3	0.55		**3**	2.14	**3**			**3**			**3**	
5	0.60	0.25	**5**	2.09	**5**			**5**			**5**	
7	0.62		**7**	2.16	**7**			**7**			**7**	
10	0.67	0.27	**10**	2.04	**10**			**10**			**10**	
15	0.71		**15**	1.97	**15**			**15**			**15**	
20	0.74	0.26	**20**	1.90	**20**			**20**			**20**	
30	0.85		**30**	1.82	**30**	0.00		**30**	0.00		**30**	
40	0.97	0.27	**40**	1.77	**40**	0.00		**40**	0.00		**40**	
60	1.04		**60**	1.68	**60**	0.00		**60**	0.00		**60**	
90	1.20	0.25	**90**	1.57	**90**	0.00		**90**	0.00		**90**	
120	1.24		**120**	1.45	**120**	0.01		**120**	0.00		**120**	
150	1.32	0.27	**150**	1.39	**150**	0.02		**150**	0.00		**150**	
180	1.38		**180**	1.34	**180**	0.04		**180**	0.00		**180**	
210	1.43	0.26	**210**	1.30	**210**	0.06		**210**	0.00		**210**	
240	1.46		**240**	1.27	**240**	0.09		**240**	0.01		**240**	
300	1.50	0.25	**300**	1.19	**300**	0.12		**300**	0.03		**300**	
360	1.59		**360**	1.12	**360**	0.15		**360**	0.06		**360**	
420	1.65	0.27	**420**	1.08	**420**	0.19		**420**	0.09		**420**	
480	1.70		**480**	1.04	**480**	0.23		**480**	0.09		**480**	
540	1.74	0.25	**540**	1.01	**540**	0.27		**540**	0.09		**540**	
600	1.77		**600**	0.97	**600**	0.32		**600**	0.09		**600**	
720	1.80	0.25	**720**	0.94	**720**	0.39		**720**	0.09		**720**	
840	1.87		**840**	0.90	**840**	0.43		**840**	0.09		**840**	
960	1.91	0.27	**960**	0.84	**960**	0.47		**960**	0.09		**960**	
1080	1.94		**1080**	0.79	**1080**	0.52		**1080**	0.09		**1080**	
1200	1.98	0.25	**1200**	0.75	**1200**	0.57		**1200**	0.09		**1200**	
1320	2.02		**1320**	0.73	**1320**	0.62		**1320**	0.09		**1320**	
1440	2.07	0.27	**1440**	0.70	**1440**	0.65		**1440**	0.09		**1440**	
1560	2.20		**1560**	0.69	**1560**	0.67		**1560**	0.09		**1560**	
1680	2.32	0.25	**1680**	0.66	**1680**	0.69		**1680**	0.09		**1680**	
1800	2.50		**1800**	0.65	**1800**	0.73		**1800**	0.09		**1800**	
1920	2.54	0.27	**1920**	0.63	**1920**	0.75		**1920**	0.09		**1920**	
2040	2.55		**2040**	0.61	**2040**	0.76		**2040**	0.09		**2040**	
2160	2.61	0.25	**2160**	0.59	**2160**	0.77		**2160**	0.09		**2160**	
2280	2.63		**2280**	0.58	**2280**	0.78		**2280**	0.09		**2280**	
2400	2.64	0.27	**2400**	0.57	**2400**	0.79		**2400**	0.09		**2400**	
2520	2.66		**2520**	0.56	**2520**	0.81		**2520**	0.09		**2520**	
2640	2.68	0.26	**2640**	0.55	**2640**	0.82		**2640**	0.09		**2640**	
2760	2.70		**2760**	0.53	**2760**	0.83		**2760**	0.09		**2760**	
2880	2.74	0.28	**2880**	0.50	**2880**	0.85		**2880**	0.09		**2880**	
3000			**3000**		**3000**			**3000**			**3000**	
3120			**3120**		**3120**			**3120**			**3120**	
3240			**3240**		**3240**			**3240**			**3240**	
3360			**3360**		**3360**			**3360**			**3360**	
3480			**3480**		**3480**			**3480**			**3480**	
3600			**3600**		**3600**			**3600**			**3600**	
3720			**3720**		**3720**			**3720**			**3720**	
3840			**3840**		**3840**			**3840**			**3840**	
3960			**3960**		**3960**			**3960**			**3960**	
4080			**4080**		**4080**			**4080**			**4080**	
4200			**4200**		**4200**			**4200**			**4200**	
4320			**4320**		**4320**			**4320**			**4320**	
Total time pumped(min):				2880		**W/L**	**9.86**		**W/L**	**13.95**		**W/L**
Average yield (l/s):				0.27								

Telephone: 043-732 1211
Fax no: 043-732 1422
Fax to e-mail: 0866 717 732
E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PR0JECT #	P1586
BBR	CHRISTOPHER
PRODUCTION BONUS:	THANDO
	SAMUEL
EC meter number	

CONSULTANT: AURECON
DISTRICT: BELFAST
PROVINCE: MPUMALANGA
FARM / VILLAGE NAME : BELFAST
DATE TESTED: 13/04/2016

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS:	hddd ° mm ' ss.s "	hddd ° mm.mmm '	hddd.ddddd °
LATITUDE:	° ' "	° ' OR	25.75330 ° OR
LONGITUDE:	° ' "	° '	29.96888 °

BOREHOLE NO: BRBH5
TRANSMISSIVITY VALUE:
TYPE INSTALLATION: NEW BOREHOLE
BOREHOLE DEPTH: (mbgl) 80.30

COMMENTS:

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	DATA CAPTURED BY:	AVN
Date sample taken	14/04/2016		If consultant took sample, give name:			DATA CHECKED BY:	AVN
Time sample taken	08H30						

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:		l/s	WATER STRIKE 1:			m
BLOW YIELD:		m	STEP 2:		l/s	WATER STRIKE 2:			m
STATIC WATER LEVEL:		m	STEP 3:		l/s	WATER STRIKE 3:			m
PUMP INSTALLATION DEPTH:		m	STEP 4:		l/s	**COMMENTS:**			
RECOVERY:			STEP 5:		l/s				
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)			
AFTER CONSTANT:		h	STEP DURATION:		min				

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	80.30
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	16.44
CASING DETECTION:	NO	1	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	0	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	50
LOGGERS FOR WATERLEVEL MONITORING	NO	0	LOGGERS FOR pH AND EC:	NO	0

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

NAME: _____ **SIGNATURE:** _____
DESIGNATION: _____ **DATE:** _____

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1586	MAP REFERENCE:	0	PROVINCE:	MPUMALANGA
BOREHOLE NO:	BRBH5			DISTRICT:	BELFAST
ALT BH NO:	0			SITE NAME:	BELFAST
ALT BH NO:	0				

BOREHOLE DEPTH (m)	80.30	DATUM LEVEL ABOVE CASING (m):	0.15	EXISTING PUMP:	0
WATER LEVEL (mbdl):	13.85	CASING HEIGHT: (magl):	0.30	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	61.87	DIAM PUMP INLET (mm):	165.00	PUMP TYPE:	BP10

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE:	13/04/2016	TIME:	12H00		DATE:	13/04/2016	TIME:	13H00		DATE:	13/04/2016	TIME:	14H00	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.08		1		1	0.79		1		1	1.61		1	
2	0.08		2		2	0.85		2		2	1.69		2	
3	0.09		3		3	1.05	0.80	3		3	2.00		3	
5	0.09	0.42	5		5	1.08		5		5	2.68	1.61	5	
7	0.22		7		7	1.10	0.81	7		7	3.07		7	
10	0.34	0.42	10		10	1.14		10		10	3.39	1.60	10	
15	0.39		15		15	1.23	0.82	15		15	3.85		15	
20	0.43	0.43	20		20	1.26		20		20	4.02	1.61	20	
30	0.50		30		30	1.33	0.81	30		30	4.26		30	
40	0.55	0.42	40		40	1.40		40		40	4.45	1.62	40	
50	0.59		50		50	1.46	0.81	50		50	4.60		50	
60	0.62	0.42	60		60	1.52		60		60	4.67	1.61	60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
pH			150		pH			150		pH			150	
TEMP	20.70	°C	180		TEMP	19.40	°C	180		TEMP	21.50	°C	180	
EC	153.00	µS/cm	210		EC	157.00	µS/cm	210		EC	167.00	µS/cm	210	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:	13/04/2016	TIME:	15H00		DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	5.60		1	46.13	1			1		1			1	
2	10.18		2	40.34	2			2		2			2	
3	13.45	3.50	3	32.40	3			3		3			3	
5	21.88		5	16.90	5			5		5			5	
7	30.02	3.51	7	5.33	7			7		7			7	
10	43.10		10	1.65	10			10		10			10	
12	48.00	3.51	15	1.53	15			15		15			15	
13	48.00	1.65	20	1.39	20			20		20			20	
14	48.00	1.50	30	1.25	30			30		30			30	
15	48.00	1.48	40	1.20	40			40		40			40	
			50	1.14	50			50		50			50	
			60	1.10	60			60		60			60	
			70	1.04	70			70		70			70	
			80	1.00	80			80		80			80	
			90	0.96	90			90		90			90	
			100	0.92	100			100		100			100	
			110	0.84	110			110		110			110	
			120	0.79	120			120		120			120	
pH			150	0.74	pH			150		pH			150	
TEMP		°C	180	0.70	TEMP		°C	180		TEMP		°C	180	
EC		µS/cm	210		EC		µS/cm	210		EC		µS/cm	210	
			240					240					240	
			300					300					300	
			360					360					360	

S/W/L:(mbch) 13.68

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1586	MAP REFERENCE:	25.7533	PROVINCE:	MPUMALANGA
BOREHOLE NO:	BRBH5		29.96888	DISTRICT:	BELFAST
ALT BH NO:	0			SITE NAME:	BELFAST
ALT BH NO:	0				
BOREHOLE DEPTH:	80.30	DATUM LEVEL ABOVE CASING (m):	0.15	EXISTING PUMP:	0
WATER LEVEL (mbdl):	14.17	CASING HEIGHT: (magl):	0.30	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	61.87	DIAM PUMP INLET(mm):	165	PUMP TYPE:	BP10

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				**TEST COMPLETED**					
DATE:	14/04/2016	TIME:	06H40	DATE:		TIME:		TYPE OF PUMP:	BP10

					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3	
					NR:			NR:			NR:	
DISCHARGE BOREHOLE					Distance(m);			Distance(m);			Distance(m);	
TIME	DRAW	YIELD	TIME	RECOVERY	TIME:	Drawdown	Recovery	TIME:	Drawdown	Recovery	TIME:	Drawdown
(MIN)	DOWN (M)	(L/S)	MIN	(M)	(min)	m	(m)	(min)	(m)		(min)	(m)
1	0.88		**1**	45.56	**1**			**1**			**1**	
2	1.08		**2**	39.18	**2**			**2**			**2**	
3	1.66	1.48	**3**	31.78	**3**			**3**			**3**	
5	2.60	1.61	**5**	25.63	**5**			**5**			**5**	
7	3.10		**7**	20.92	**7**			**7**			**7**	
10	3.35	1.62	**10**	16.66	**10**			**10**			**10**	
15	3.53		**15**	5.17	**15**			**15**			**15**	
20	3.63	1.61	**20**	4.53	**20**			**20**			**20**	
30	3.84		**30**	4.47	**30**			**30**			**30**	
40	3.98	1.62	**40**	4.34	**40**			**40**			**40**	
60	4.20		**60**	4.27	**60**			**60**			**60**	
90	4.53	1.60	**90**	4.21	**90**			**90**			**90**	
120	4.82		**120**	4.13	**120**			**120**			**120**	
150	4.95	1.61	**150**	4.08	**150**			**150**			**150**	
180	5.16		**180**	4.04	**180**			**180**			**180**	
210	5.34	1.60	**210**	3.94	**210**			**210**			**210**	
240	5.46		**240**	3.83	**240**			**240**			**240**	
300	12.48	1.61	**300**	3.77	**300**			**300**			**300**	
360	18.12		**360**	3.53	**360**			**360**			**360**	
420	21.46	1.62	**420**	3.42	**420**			**420**			**420**	
480	25.18		**480**	3.34	**480**			**480**			**480**	
540	26.05	1.60	**540**	3.25	**540**			**540**			**540**	
600	29.32		**600**	3.18	**600**			**600**			**600**	
720	31.74	1.61	**720**	3.13	**720**			**720**			**720**	
840	33.81		**840**	3.07	**840**			**840**			**840**	
960	35.60	1.62	**960**	3.02	**960**			**960**			**960**	
1080	38.12		**1080**	2.94	**1080**			**1080**			**1080**	
1200	40.10	1.60	**1200**	2.81	**1200**			**1200**			**1200**	
1320	41.89		**1320**	2.73	**1320**			**1320**			**1320**	
1440	43.16	1.62	**1440**	2.53	**1440**			**1440**			**1440**	
1554	47.86		**1560**	2.41	**1560**			**1560**			**1560**	
1556	47.86	1.12	**1680**		**1680**			**1680**			**1680**	
1558	47.86	1.10	**1800**		**1800**			**1800**			**1800**	
1560	47.86	1.00	**1920**		**1920**			**1920**			**1920**	
2040			**2040**		**2040**			**2040**			**2040**	
2160			**2160**		**2160**			**2160**			**2160**	
2280			**2280**		**2280**			**2280**			**2280**	
2400			**2400**		**2400**			**2400**			**2400**	
2520			**2520**		**2520**			**2520**			**2520**	
2640			**2640**		**2640**			**2640**			**2640**	
2760			**2760**		**2760**			**2760**			**2760**	
2880			**2880**		**2880**			**2880**			**2880**	
3000			**3000**		**3000**			**3000**			**3000**	
3120			**3120**		**3120**			**3120**			**3120**	
3240			**3240**		**3240**			**3240**			**3240**	
3360			**3360**		**3360**			**3360**			**3360**	
3480			**3480**		**3480**			**3480**			**3480**	
3600			**3600**		**3600**			**3600**			**3600**	
3720			**3720**		**3720**			**3720**			**3720**	
3840			**3840**		**3840**			**3840**			**3840**	
3960			**3960**		**3960**			**3960**			**3960**	
4080			**4080**		**4080**			**4080**			**4080**	
4200			**4200**		**4200**			**4200**			**4200**	
4320			**4320**		**4320**			**4320**			**4320**	
Total time pumped(min):				1560		**W/L**			**W/L**			**W/L**
Average yield (l/s):				1.62								

Telephone: 043-732 1211
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E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PR0JECT #	P1582
BBR	CHRISTOPHER
PRODUCTION BONUS:	THANDO
	SAMUEL
EC meter number	

CONSULTANT: AURECON
DISTRICT: BELFAST
PROVINCE: MPUMALANGA
FARM / VILLAGE NAME : BELFAST
DATE TESTED: 08/04/2016

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS:	hddd ° mm ' ss.s "	hddd ° mm.mmm '	hddd.ddddd °
LATITUDE:	° ' "	° ' OR	25.75992 ° OR
LONGITUDE:	° ' "	° '	29.96480 °

BOREHOLE NO: BRBH6
TRANSMISSIVITY VALUE:
TYPE INSTALLATION: NEW BOREHOLE
BOREHOLE DEPTH: (mbgl) 79.60

COMMENTS:

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	DATA CAPTURED BY:	AVN
Date sample taken	11/04/2016		If consultant took sample, give name:			DATA CHECKED BY:	AVN
Time sample taken	07H50						

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:		l/s	WATER STRIKE 1:			m
BLOW YIELD:		m	STEP 2:		l/s	WATER STRIKE 2:			m
STATIC WATER LEVEL:		m	STEP 3:		l/s	WATER STRIKE 3:			m
PUMP INSTALLATION DEPTH:		m	STEP 4:		l/s	**COMMENTS:**			
RECOVERY:			STEP 5:		l/s				
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)			
AFTER CONSTANT:		h	STEP DURATION:		min				

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	79.60
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	15.92
CASING DETECTION:	NO	1	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	0	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	100
LOGGERS FOR WATERLEVEL MONITORING	NO	0	LOGGERS FOR pH AND EC:	NO	0

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

NAME: _____ **SIGNATURE:** _____
DESIGNATION: _____ **DATE:** _____

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1582	MAP REFERENCE:	0	PROVINCE:	MPUMALANGA
BOREHOLE NO:	BRBH6			DISTRICT:	BELFAST
ALT BH NO:	0			SITE NAME:	BELFAST
ALT BH NO:	0				
BOREHOLE DEPTH (m)	79.60	DATUM LEVEL ABOVE CASING (m):	0.27	EXISTING PUMP:	0
WATER LEVEL (mbdl):	14.95	CASING HEIGHT: (magl):	0.43	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	61.87	DIAM PUMP INLET (mm):	165.00	PUMP TYPE:	BP10

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE:	08/04/2016	TIME:	12H20		DATE:	08/04/2016	TIME:	13H20		DATE:	08/04/2016	TIME:	14H20	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.17		**1**		**1**	0.79		**1**		**1**	1.27		**1**	
2	0.18		**2**		**2**	0.83	0.52	**2**		**2**	1.50	1.47	**2**	
3	0.18	0.27	**3**		**3**	0.85		**3**		**3**	1.69	1.50	**3**	
5	0.19	0.34	**5**		**5**	0.87	0.52	**5**		**5**	2.05		**5**	
7	0.20		**7**		**7**	0.89		**7**		**7**	2.40	1.51	**7**	
10	0.21	0.34	**10**		**10**	0.91	0.53	**10**		**10**	2.86		**10**	
15	0.22		**15**		**15**	0.95		**15**		**15**	3.18	1.52	**15**	
20	0.24	0.35	**20**		**20**	0.99	0.53	**20**		**20**	3.25		**20**	
30	0.36		**30**		**30**	1.05		**30**		**30**	3.47	1.52	**30**	
40	0.52	0.35	**40**		**40**	1.12	0.52	**40**		**40**	3.69		**40**	
50	0.59		**50**		**50**	1.17		**50**		**50**	3.80	1.50	**50**	
60	0.64	0.34	**60**		**60**	1.22	0.52	**60**		**60**	3.97		**60**	
70			**70**		**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP	20.20	°C	**180**		**TEMP**	20.40	°C	**180**		**TEMP**	21.00	°C	**180**	
EC	159.00	µS/cm	**210**		**EC**	160.00	µS/cm	**210**		**EC**	159.00	µS/cm	**210**	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:	08/04/2016	TIME:	15H20		DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	4.25		**1**	44.40	**1**			**1**		**1**			**1**	
2	4.93		**2**	41.67	**2**			**2**		**2**			**2**	
3	5.20	3.52	**3**	35.83	**3**			**3**		**3**			**3**	
5	9.93		**5**	19.87	**5**			**5**		**5**			**5**	
7	13.81	3.51	**7**	6.23	**7**			**7**		**7**			**7**	
10	19.89		**10**	2.78	**10**			**10**		**10**			**10**	
15	29.05	3.53	**15**	2.51	**15**			**15**		**15**			**15**	
20	37.67		**20**	2.33	**20**			**20**		**20**			**20**	
24	46.92	3.52	**30**	2.05	**30**			**30**		**30**			**30**	
26	46.92	2.22	**40**	1.86	**40**			**40**		**40**			**40**	
28	46.92	2.16	**50**	1.68	**50**			**50**		**50**			**50**	
30	46.92	2.15	**60**	1.50	**60**			**60**		**60**			**60**	
			70	1.41	**70**			**70**		**70**			**70**	
			80	1.30	**80**			**80**		**80**			**80**	
			90	1.25	**90**			**90**		**90**			**90**	
			100	1.15	**100**			**100**		**100**			**100**	
			110	1.07	**110**			**110**		**110**			**110**	
			120	0.95	**120**			**120**		**120**			**120**	
pH			**150**	0.90	**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**	0.86	**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**	0.73	**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	
			240					**240**					**240**	
			300					**300**					**300**	
			360					**360**					**360**	

S/W/L:(mbch) 13.95

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P1582	MAP REFERENCE:	25.75992	PROVINCE:	MPUMALANGA
BOREHOLE NO:	BRBH6		29.9648	DISTRICT:	BELFAST
ALT BH NO:	0			SITE NAME:	BELFAST
ALT BH NO:	0				
BOREHOLE DEPTH:	79.60	DATUM LEVEL ABOVE CASING (m):	0.27	EXISTING PUMP:	0
WATER LEVEL (mbdl):	15.70	CASING HEIGHT: (magl):	0.43	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	61.87	DIAM PUMP INLET(mm):	165	PUMP TYPE:	BP10

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				**TEST COMPLETED**					
DATE:	09/04/2016	TIME:	07H00	DATE:		TIME:		TYPE OF PUMP:	BP10

					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3	
					NR:			NR:			NR:	
DISCHARGE BOREHOLE					Distance(m);			Distance(m);			Distance(m);	
TIME	DRAW	YIELD	TIME	RECOVERY	TIME:	Drawdown	Recovery	TIME:	Drawdown	Recovery	TIME:	Drawdown
(MIN)	DOWN (M)	(L/S)	MIN	(M)	(min)	m	(m)	(min)	(m)		(min)	(m)
1	0.99		**1**	2.32	**1**			**1**			**1**	
2	1.50		**2**	2.24	**2**			**2**			**2**	
3	1.91		**3**	2.10	**3**			**3**			**3**	
5	2.42	1.39	**5**	2.06	**5**			**5**			**5**	
7	2.63	1.50	**7**	2.01	**7**			**7**			**7**	
10	2.78		**10**	1.98	**10**			**10**			**10**	
15	3.01	1.51	**15**	1.96	**15**			**15**			**15**	
20	3.16		**20**	1.94	**20**			**20**			**20**	
30	3.47		**30**	1.92	**30**			**30**			**30**	
40	3.63	1.51	**40**	1.90	**40**			**40**			**40**	
60	3.97		**60**	1.89	**60**			**60**			**60**	
90	4.20	1.51	**90**	1.89	**90**			**90**			**90**	
120	4.27		**120**	1.88	**120**			**120**			**120**	
150	4.30	1.53	**150**	1.86	**150**			**150**			**150**	
180	4.30		**180**	1.84	**180**			**180**			**180**	
210	4.32	1.53	**210**	1.82	**210**			**210**			**210**	
240	4.34		**240**	1.82	**240**			**240**			**240**	
300	4.36	1.50	**300**	1.80	**300**			**300**			**300**	
360	4.38		**360**	1.77	**360**			**360**			**360**	
420	4.37	1.54	**420**	1.75	**420**			**420**			**420**	
480	4.39		**480**	1.72	**480**			**480**			**480**	
540	4.39	1.52	**540**	1.70	**540**			**540**			**540**	
600	4.39		**600**	1.68	**600**			**600**			**600**	
720	4.39	1.51	**720**	1.66	**720**			**720**			**720**	
840	4.39		**840**	1.63	**840**			**840**			**840**	
960	4.39	1.53	**960**	1.61	**960**			**960**			**960**	
1080	4.40		**1080**	1.58	**1080**			**1080**			**1080**	
1200	4.40	1.55	**1200**	1.56	**1200**			**1200**			**1200**	
1320	4.40		**1320**	1.53	**1320**			**1320**			**1320**	
1440	4.40	1.55	**1440**	1.50	**1440**			**1440**			**1440**	
1560	4.39		**1560**	1.47	**1560**			**1560**			**1560**	
1680	4.39	1.55	**1680**	1.44	**1680**			**1680**			**1680**	
1800	4.40		**1800**	1.39	**1800**			**1800**			**1800**	
1920	4.41	1.56	**1920**	1.37	**1920**			**1920**			**1920**	
2040	4.42		**2040**	1.34	**2040**			**2040**			**2040**	
2160	4.42	1.54	**2160**	1.31	**2160**			**2160**			**2160**	
2280	4.43		**2280**	1.29	**2280**			**2280**			**2280**	
2400	4.44	1.54	**2400**	1.27	**2400**			**2400**			**2400**	
2520	4.44		**2520**	1.25	**2520**			**2520**			**2520**	
2640	4.45	1.55	**2640**	1.23	**2640**			**2640**			**2640**	
2760	4.46		**2760**	1.21	**2760**			**2760**			**2760**	
2880	4.47	1.55	**2880**	1.19	**2880**			**2880**			**2880**	
3000			**3000**		**3000**			**3000**			**3000**	
3120			**3120**		**3120**			**3120**			**3120**	
3240			**3240**		**3240**			**3240**			**3240**	
3360			**3360**		**3360**			**3360**			**3360**	
3480			**3480**		**3480**			**3480**			**3480**	
3600			**3600**		**3600**			**3600**			**3600**	
3720			**3720**		**3720**			**3720**			**3720**	
3840			**3840**		**3840**			**3840**			**3840**	
3960			**3960**		**3960**			**3960**			**3960**	
4080			**4080**		**4080**			**4080**			**4080**	
4200			**4200**		**4200**			**4200**			**4200**	
4320			**4320**		**4320**			**4320**			**4320**	
Total time pumped(min):				2880		**W/L**			**W/L**			**W/L**
Average yield (l/s):				1.56								