GEOHYDROLOGY REPORT

FOR THE WELTEVREDEN PROJECT

NORTHERN COAL

UPDATED: FEBRUARY 2011

Environmental Solutions Provider

Prepared By:
Digby Wells & Associates
Environmental Solutions Provider
Private Bag X10046,
Randburg, 2125,
South Africa
Tel: +27 (11) 789-9495
Fax: +27 (11) 789-9498
E-Mail : info@digbywells.co.za

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1 INTRODUCTION

Northern Coal (Pty) Ltd (Northern Coal) is in possession of an approved Prospecting Right for coal on portion 15 and 16 of the farm Weltevreden 381 JT within the Belfast area of the Mpumalanga Province. Through feasibility studies together with the current price and demand for coal within the internal market, Northern Coal has found it economically viable to undertake mining operations on the above mentioned portions. Subsequently Northern Coal has submitted a Mining Right Application in order to undertake mining activities on portion 15 and 16 of the farm Weltevreden 381 JT (Plan 1, Appendix A).

Digby Wells and Associates (Pty) Ltd (DWA) have been appointed by Northern Coal as independent environmental consultants to undertake the environmental investigations and document compilation required by the various governmental departments in support of the Mining Right Application and to obtain environmental authorisation for the proposed project from both the Department of Minerals and Energy and Mpumalanga Department of Agriculture and Land Affairs.

This report addresses the geohydrological issues and expected impacts of the Weltevreden development.

2 GEOLOGY

The Weltevreden Colliery is located within the Witbank coal field, forming part of the Karoo basin present over the central areas of South Africa (Plan 2, Appendix A).

2.1 Regional geology

2.1.1 Stratigraphy

The basement rock within the Karoo Basin is overlain by the Karoo Super Group. The basement of the Karoo Super Group is the Dwyka tillites that are fairly regularly deposited over the basin with the exception of paleo-topographical highs. The Dwyka tillites are overlain by the Vryheid formation which hosts the coal seams. The Vryheid formation consists of various sequences of sandstones, shales and siltstones with the various coal seams located within them. Higher units of the Karoo Super Group are not present within the study area.

2.1.2 Structural geology

During the Jurassic period a large number of dolerite dykes and sills intruded into the Karoo formation acting as important geological structures diverting and impending groundwater movements.

2.1.3 Geochemistry

The following table summarises the geochemistry for the different coal seams in the Witbank coal field.

Table 1: Typical analysis (air dry) for the different coal seams in the Witbank coal field (Smith & Whittaker, 1986)

	Raw coal				Washed coal							
	%H2O	%ash	%VM	CV MJ/kg	RD	%yield	%H2O	%ash	%VM	CV MJ/kg	S.I.	Roga index
No. 1 Seam Witbank area	1.7	25.4	21.0	24.0	1.6	38.2	2.0	9.7	25.2	29.1	-	-
No. 2 Seam Ogies area												
Top bench 0.97m	5.6	27.5	20.7	21.1	-	-	-	-	-	-	-	-
Middle bench 0.47m	5.3	21.3	21.2	21.2	1.6	65.6	5.7	14.7	23.6	25.3	-	-
Bottom bench 5.47m	3.7	23.5	22.4	22.4	1.6	64.6	4.5	13.2	26.8	26.3	-	-
No. 2 Seam Witbank area												
Bench 5 - 1.00m	1.7	26.6	18.4	20.2	1.6	57.8	2.4	11.5	26.8	29.3	1.5	22
Bench 4 -1.96m	2.3	19.2	20.4	25.5	1.6	82.3	2.4	15.8	21.5	26.3	1	0
Bench 3 -0.33m	2.1	8.3	27.7	30.6	1.6	98.0	2.1	7.8	27.9	30.6	1.5	22
Bench 2 -1.24 m	1.9	18.2	21.3	26.6	1.6	83.1	1.9	14.2	21.8	28.2	1	0
Bench 1 -1.26m	1.9	9.1	33.8	30.8	1.6	95.8	1.9	7.7	34.4	31.2	3	62
No. 4 Seam Witbank area	2.6	27.6	20.7	22.2	1.6	62.5	2.5	17	22.4	26.1	-	-
No. 4 Seam Ogies area	30.8	30.3	22.7	19.9	1.6	62.3	3.9	14.4	27.5	26.5	-	-
No. 5 Seam Witbank area	2.5	13.1	32.0	28.7	1.6	88.7	2.5	9.8	33.4	30.0	2.5	45

2.1.4 Geomorphology

Weathering of the Karoo strata over the study area occurs between 5 m and 12 m below surface level (Hodgson & Krantz, 1998). The pale topography is a result of the extensive glaciations that had occurred about 320 Ma during the late Carboniferous to early

Permian period. The lower lying coal seams (No.1 and No.2 seams) were generally formed within lower lying areas with the higher seams being more continuous. However later erosion has resulted in the overlying No.4 and No.5 seams being eroded away in current topographical lower lying areas.

2.1.5 Economic geology

Weltevreden Colliery falls within the Witbank coal field. This coal field has been extensively mined since 1895. The economically important coal seams within the coal field are the 1, 2, 4 and 5 seams with the 2 and 4 seams being mostly mined as board and pillar operations.

2.2 Site specific geology

2.2.1 Stratigraphy

The prospecting area on the farm Weltevreden is underlain by sediments and coal measures of the Vryheid and Dwyka Formations of the Ecca Group which rests on the quartzite of the Transvaal Supergroup. This quartzite outcrop 1 km east of the prospecting boundary and are steeply dipping towards the west.

This coal field is correlated with the Witbank coal field which typically has 5 coal seams developed and is numbered from bottom upwards.

A very thin coal seam is developed and occurs approximately 2 meters above the Dwyka tillite. The maximum thickness is 0.53 meters and this seam could be correlated with the No. 1 seam.

The No. 2 seam occurs approximately 10 meters above the Dwyka tillite. The seam thickness increases from 1.2 meter in the north to 3.62 meters towards the centre of the prospecting area and reaches a maximum 4.15 meters in the south western portion. The seam thickness decreases to the south, splits into two seams of about 30 cm each separated by a mudstone and sub outcrops in the southwest as a carbonaceous mudstone.

The overall dip of the No. 2 seam is south-westerly in the north but has a southerly attitude towards the south at the southern portion of the area.

2.2.2 Structural geology

A Post-Karoo dolerite sill intruded into the sediments below the coal measures in places. The top contact forms a north-south trending dome structure but only displays a slight undulating top contact towards the south. This sill assimilated the No. 2 seam towards the east and west at elevations where the coal measures would be present

2.2.3 Geochemistry

The coal intersection of the cores was split-sampled and individually assayed by Midlab CC., Middelburg. It was found that there is a tendency of quality differences regarding the upper, middle and lower portions of the seam in individual intersections. However, this tendency could not be confirmed over the entire area (Nel, 2008). The overall quality of the total No.2 coal seam and acid generating potential will be discussed in section 5 of this report.

2.2.4 Geomorphology

No weathering profiles were available to describe site specific geomorphology at the time of compiling this report.

2.2.5 Economic geology

An area of 2 190 000 m² is underlain by the No. 2 coal seam and to obtain the dimensions of the area, the area was digitised and calculated using Surfer and Didger software (Nel, 2008). The area underlain by No. 2 seam is between the sub outcrop in the west and the eastern boundary of Portions 15 and 16. The arrhythmic mean of the No.2 Seam thickness is 2,69m. The calculated arrhythmic mean for the strip ratio in the prospecting area (coal in situ) is 5.29:1. The resource estimated for Weltevreden can be seen in Table 2.

Table 2: Resource estimation for Weltevreden

Property	Status	Block	Seam	Strip Ratio*	GTIS (Mt)**	Geology Loss %	Mining Loss %	Gross ROM*** (Mt)
Ptn 15 & 16	Proven Resource	Opencast	No.2	5:1	3.962	10	5	3.368
Ptn 15 & 16	Proven Resource	Opencast	No.2	> 5:1	4.875	10	5	4.144
Total					**8.837**			**7.512**

Strip Ratio* – Bank cubic metres of overlain / ton of coal in situ

GTIS (Mt)** – Gross tons in situ (Million tons)

ROM *** Run off Mine

3 CLIMATE

The area is characterised by moderate summers, cold winters and summer rainfall. The average rainfall in the target area is 768 mm per annum. The rainfall distribution and total rainfall is typical of the Highveld region. The region is characterised by thunderstorms in the summer. Temperatures are also typical of what could be expected in the Highveld region, although lower temperatures could be expected on the high lying regions (ELM, 2006).

4 GEOHYDROLOGY

4.1 Conceptual geohydrology model

The natural geohydrological system within the Witbank coal field consists of three superimposed aquifers namely an upper weathered aquifer, a fractured Karoo aquifer and a fractured pre-Karoo aquifer (Hodgson & Krantz, 1998).

The upper weathered aquifer consists of material weathered in situ and transported as part of the erosion process. The depth to weathering is generally between 1 m and 15 m from surface and the water level varies between 5 m and 10 m below ground level (mbgl). The flow mechanism within the weathered aquifer is porous flow. The water quality is generally good due to years of dynamic groundwater flow resulting in the leaching of soluble salts.

The fractured Karoo aquifer consists of the various lithologies of siltstone, shale, sandstone and the coal seams. The pores of the geological units are generally well cemented and the principle flow mechanism is fractured flow along secondary structures e.g. faults, bedding plane fractures etc. The intrusion of the fractured aquifer by dolerite dykes and sills has led to the formation of preferential flow paths along the contacts of these lithologies due to the formation of cooling joints. The dykes may act as permeable or semi-permeable features to impede flow across the dykes.

The fractured pre-Karoo aquifer is separated from the overlying fractured Karoo aquifer by Dwyka tillites which act as an aquiclude where present. The flow mechanism is fracture flow as can be expected from the crystalline nature of the granite rocks. The water quality is generally characterised by high fluoride levels which limits exploitation of this aquifer in combination with the general low yields, deep (expensive) drilling and the low recharge (Grobbelaar et al, 2004).

Mining of the coal seams has resulted in the introduction of an artificial aquifer system which generally dominates the groundwater flow on a local and regional scale.

4.2 Hydrocensus

A hydrocensus was conducted by DWA personnel within a 2km radius from the proposed project boundary during September 2008. Additional sampling and hydrocensus information were collected in May 2009 to include additional properties not accessible during the 2008 sampling run. Further fieldwork and sampling were conducted in June 2009 after it was decided to include the old Vogelstruispoort Colliery in the study for groundwater impact and risk assessment purposes. The positions of these points are shown on Plan3, Appendix A.

The purpose of these studies were to obtain information on the current hydrogeological baseline of the area, including water quality, water use, volumes used, site condition and the location of each site. Data was collected on the current groundwater users, location of water sources, current water quality and groundwater levels (where possible). A summary of the hydrocensus points collected during the field visits is presented in Table 3.

Table 3: Hydrocensus information

Site Name	Latitude	Longitude	Elevation (mamsl)	Sampled (Y/N)	Collar Height (m)	Water level (mbgl)	Equipment	Use
BT1	-25.78956	30.04019	1836	Y	-	2.35	Sub. Pump	Domestic & Livestock
BT2	-25.78640	30.03960	1845	N	-	6.61	Wind pump	Domestic & Livestock
BT3	-25.78220	30.03929	1864	Y	-	-	Wind pump	Domestic
BT4	-25.78585	30.03390	1833	Y	0.33	15.41	Sub. Pump	Domestic & Livestock
ZP1	-25.76179	30.00146	1861	N	-	-	None	None
ZP2	-25.77019	30.00165	1822	N	0.35	5.39	Sub. Pump	Domestic
WN1	-25.76746	30.02581	1886	Y	-	-	Sub. Pump	Livestock
WN3	-25.76766	30.02645	1882	Y	-	-	Hand Pump	Domestic
WN4	-25.76746	30.02581	1875	Y	0.38	5.21	Sub. Pump	Livestock
WN7	-25.75434	30.03840	1855	Y	-	9.33	Sub. Pump	Domestic
ZKBH1	-25.78694	30.01083	1810	Y	0.20	2.13	Sub. Pump	Domestic and Agriculture
VPBH1	-25.78198	30.04805	1834	Y	0.28	-	Wind pump	Domestic

4.3 Presence of boreholes and springs

During the hydrocensus two springs were identified and both were used for domestic and livestock watering however no information regarding yield estimations were available. Information collected during the public consultation process from landowners identified a number of boreholes on and around the planned mining areas mainly used for domestic and agricultural purposes. Reported yields that were abstracted per day were between 2600 – 5000 L/d (0.03 – 0.058 L/s).

Borehole yields in the weathered aquifer are generally low, ranging from 0.025 – 0.5 L/s. Borehole yield statistics for the fractured aquifer in the Ecca sediments show that the yields vary from 0.005 L/s – 1.5 L/s with an average yield of 0.5 L/s (Hodgson &Krantz).

4.4 Water levels

Water levels observed during field visits and the hydrocensus varied between 2.35 – 15.41 mbgl (meters below ground level). The values of the rest water levels and surface elevations (topography) exhibit a Bayesian relationship with reasonable correlations as indicated on Figure 1. The Bayesian relationship represents the correlation between the surface topography elevation and groundwater level elevation. Based on the results presented in Figure 1 it can safely be assumed the groundwater levels mimic surface topography.

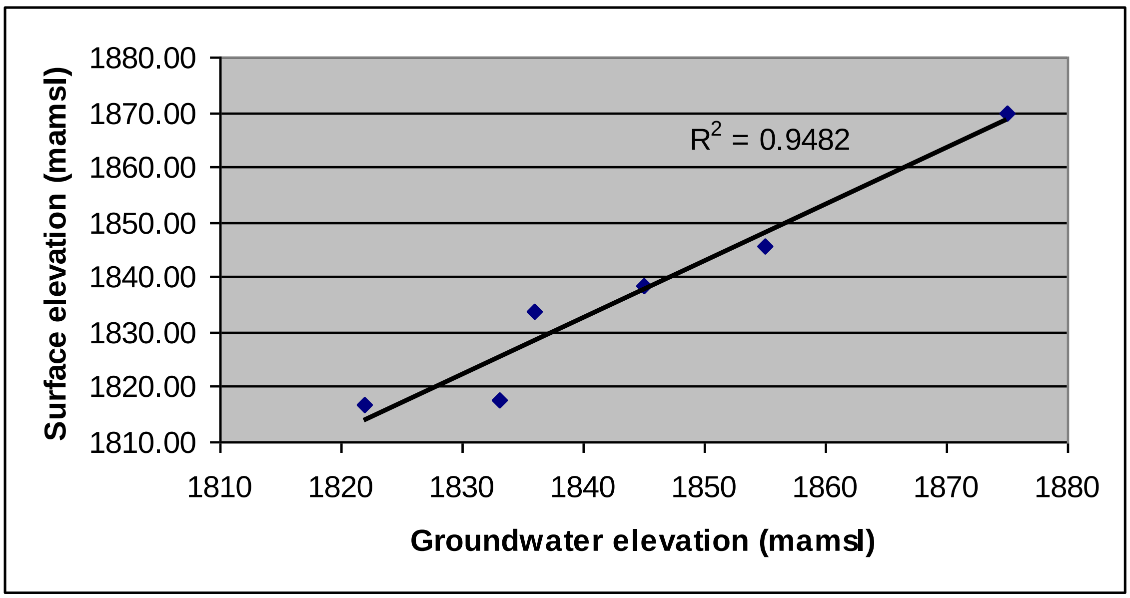


Figure 1: Bayesian correlation indicating reasonable relationship between groundwater levels and surface elevations

4.5 Flow direction and water level measurements

Rainfall that infiltrates into the weathered rock soon reaches the layer of shale underneath the weathered zone. The movement of groundwater on top of this impermeable shale layer is lateral and in the direction of the surface slope. The water may reappear on surface at fountains 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 into the groundwater level in the vicinity of streams.

Groundwater flow in the fractured aquifer is dictated by the geological characteristics and occurrence of structures. In the case of mined out voids, the groundwater flow will follow the floor contours of the deepest seam that is being mined, which is generally in a south westerly direction at Weltevreden.

4.6 Water balance

4.6.1 Groundwater recharge

Highly variable recharge occurs over the area but values are generally between 1 and 3 % of MAP (Hodgson & Krantz, 1998) for undisturbed areas. Recharge to the weathered aquifer drains towards regional surface water courses and less than 60% of the recharge discharge in streams. The remainder is withdrawn through evapotranspiration from the weathered aquifer, recharge to the deeper fractured rock aquifers or abstracted through pumping. A low vertical permeability generally exists for the fractured aquifer in the Vryheid Formation and this aquifer is recharged by interflow from the weathered aquifer.

4.6.2 Base flow

Base flow is not a measure of the volume of groundwater discharged into a river or wetland, but it is recognised that groundwater makes a contribution to the base flow component of river flow.

The total groundwater contribution to base flow in the X11D quaternary catchment is estimated to be 45 mm/a according to the Groundwater Resource Directed Measures (GRDM) data.

4.6.3 Abstraction

Total abstraction from groundwater resources in the X11D quaternary catchment as estimated by GRDM is 0.02 Mm^3/a. The exploration potential for this catchment is 3 Mm^3/a thus making 2.98 Mm^3/a available for use. From the Department of Water Affairs and Forestry (DWAF) Water Use Registering and Licensing Data Base (WARMS), X11D indicate that a registered volume of 81 004 m^3/a is being abstracted mainly agricultural use.

4.7 Dewatering and re-watering of mining areas

4.7.1 Dewatering in the opencast mining areas

Dewatering of aquifers surrounding the opencast areas will occur as a result of groundwater flow under the influence of gravity to the bottom of the pit. The radius of influence from the pit areas is calculated as a function of the hydraulic conductivity (typically 0.1 m/d in the coal seams (Hodgson & Krantz, 1998), storativity of the weathered aquifer (0.01), the depth of the pit (rather drawdown that will be achieved during life of mine) and the time that dewatering will take place.

A conservative approach was taken, where a one year timeframe was used and it was assumed that no inflow to the pit will take place during that year. Table 4 shows the values calculated for the dewatering cone of influence at the different pits. The calculated distance of the dewatering of the weathered aquifer around the opencast pit areas will be in the order of 496m. However it should be noted that the precise depths of the pits are not known at the moment thus the maximum depth of the No. 2 coal seam was used for all calculations.

Table 4: Radius of influence from dewatering at the opencast pit areas

Pit Decant ID	Pit depth (m)	K (m/d)	Storativity (S)	Radius of influence (m)
Pit 1	30	0.10	0.01	496
Pit 2	30	0.10	0.01	496
Pit 3	30	0.10	0.01	496

4.7.2 Post mine ingress into the back filled areas

Northern Coal is planning three opencast pits at Weltevreden Colliery. It is necessary to calculate the annual recharge for the future mined out areas to determine the post mine ingress volumes after rehabilitation have been completed during the closure phase (Table 5 and Table 6).

The average rainfall obtained from the South African Weather Bureau for the area is 768 mm p.a. and the highest average rainfall was 1150 mm p.a. The National Resource Directed Measures (NRDM) programme was used to obtain the mean average recharge value of 54.46 mm p.a. for the undisturbed areas. The recharge infiltration rate of 15% in previously back filled areas has been used in the following calculations from previous experience working in the Witbank Coal field.

Table 5: Recharge value for the back-fill areas for the mean annual rainfall

	Area of Opencast (m^2)	Average Rainfall (mm/a)	Recharge Percentage	Total Recharge (m^3/a)
Pit 1	1126500	768	15	129772.8
Pit 2	419300	768	15	48303.4
Pit 3	329300	768	15	37935.4

Table 6: Recharge value for the back-fill areas for the highest average rainfall

	Area of Opencast (m^2)	Average Rainfall (mm/a)	Recharge Percentage	Total Recharge (m^3/a)
Pit 1	1126500	1150	15	194321.3
Pit 2	419300	1150	15	72329.3
Pit 3	329300	1150	15	56804.3

From the above calculations it can be seen that higher recharge values are obtained from the back-filled areas when compared to the regional aquifers. High hydraulic conductivity values can be expected from the compressed spoils and waste rock.

The coal seam elevations have been obtained from the exploration drilling data completed at Weltevreden. To understand the current mining and post mining geohydrological conditions cross sections have been completed to determine where the

No. 2 coal seam intersect the surface topography. Surface and coal seam elevations indicate three possible decant points (Plan 4) as derived from the profiles drawn in Figures 2 and 3.

<u>Profile 1</u>: Line A to A' (Figure 2) indicates a strong correlation between the surface topography and the coal seam floor elevation. As a result of the coal seam forming a natural hydraulic gradient in a southern direction sites 1 and 2 will decant (Plan 4).

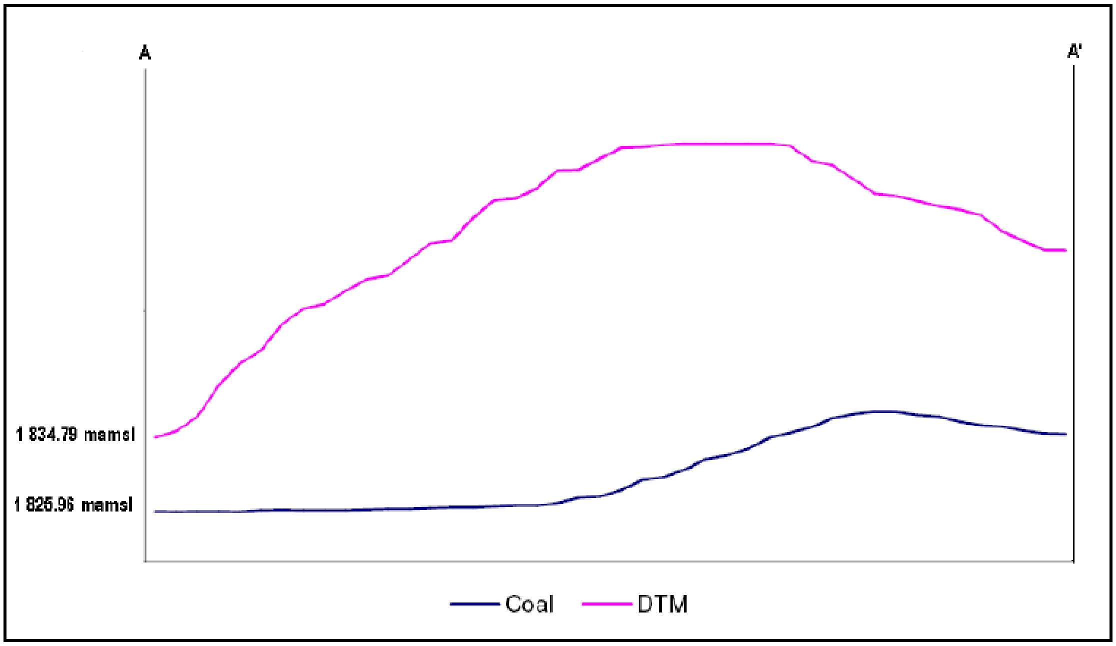


Figure 2: Cross section A to A' through the No. 2 coal seam

Profile 2: Line B to B' (

Figure 3) shows a relatively smooth coal floor elevation dipping in a south eastern direction towards the stream. Groundwater will flow towards the lowest topographic height and is likely to decant at sites 1 and 3 (Plan 4). The Weltevreden mineral rights boundary will leave a natural pillar between the stream (eastern corner) and open cast pit; however small quantities of groundwater could possibly slowly seep out at site 3.

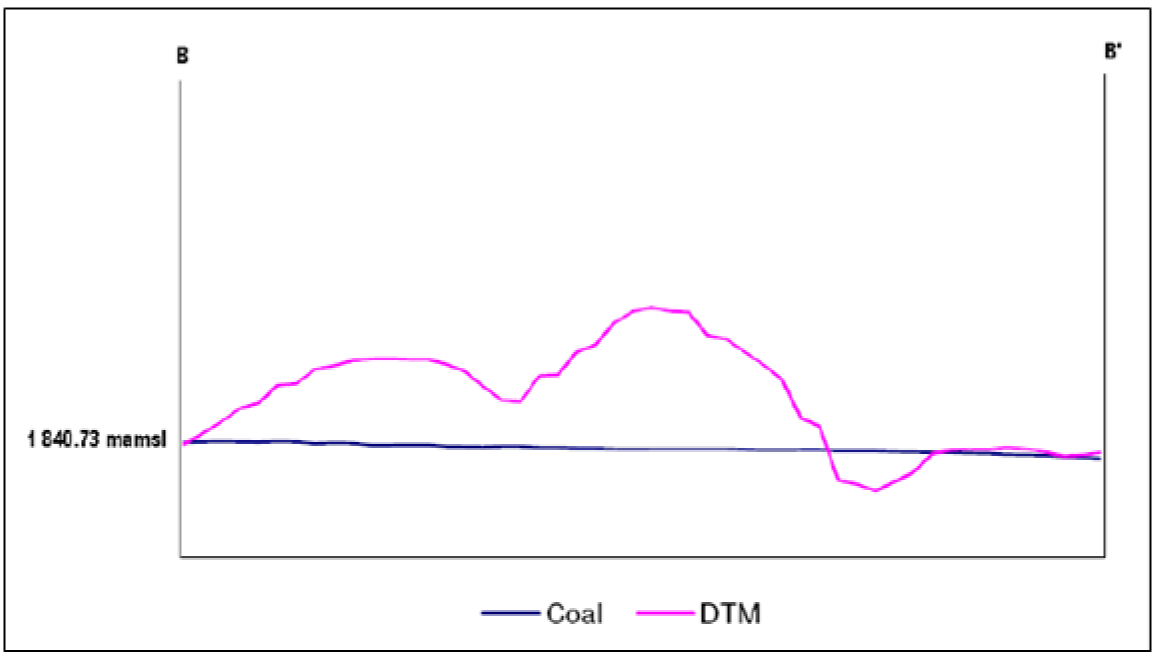


Figure 3: Cross section B to B' through the No. 2 coal seam

The appropriate mitigation measures should be put in place at the decant sites in order to effectively manage the water that is expected to decant after mine closure.

4.8 Natural recharge

The effective groundwater recharge from rainfall is the portion of rainfall that reaches the groundwater. The remainder of the rainfall comprises surface runoff, evapotranspiration and soil moisture.

The percentage of recharge for this area is estimated to be between 1 – 3% under natural conditions. For Weltevreden the average recharge will be 54.46 mm/a based on an average rainfall of 768 mm/a.

4.9 Groundwater quality

4.9.1 Classification

Samples were taken during the September 2008 and May 2009 hydrocensus survey and during the environmental assessment of the old Vogelstruispoort Colliery in June 2009 to obtain baseline information. Full macro analysis was done for the samples taken during the sampling runs. The categories of the water types as recorded under natural conditions (baseline status for this study) are shown in the Piper diagram (Figure 4).

Within the South African coal fields, the calcium-magnesium-bicarbonate (left quarter) of the Piper diagram and is characterised by freshly recharged water. The sodium bicarbonate dominant (bottom quarter) is typical of dynamic groundwater flow within the aquifers with the sodium replacing calcium and magnesium in solution. The sodium chloride dominant (right quarter) is associated with stagnant or slow moving groundwater with little or no recharge. The sulphate dominant (top quarter) is typically of water impacted by the oxidation of pyrites which is commonly associated with coal mining activities.

Six of the samples (ZPBH1, BT3, BT4, WN1, WN3 and WN7) fall within the calcium-magnesium-bicarbonate (left quarter) of the Piper plot and is characterised by freshly recharged water. Sample WN4 plots in the right quarter and signifies sodium chloride dominant water. Samples BT1 and VPBH1 indicates sulphate dominant water and is typical of water impacted by the oxidation of pyrites which is commonly associated with coal mining activities.

The groundwater is of good quality and the majority of the samples plotted within the SANS 241 class 1 (acceptable) for drinking water guidelines, except for samples:

- BT 1 (pH 3.62); and
- VPBH 1 (TDS 1132 mg/l, SO_4 587 mg/l and Mn 47.6 mg/l).

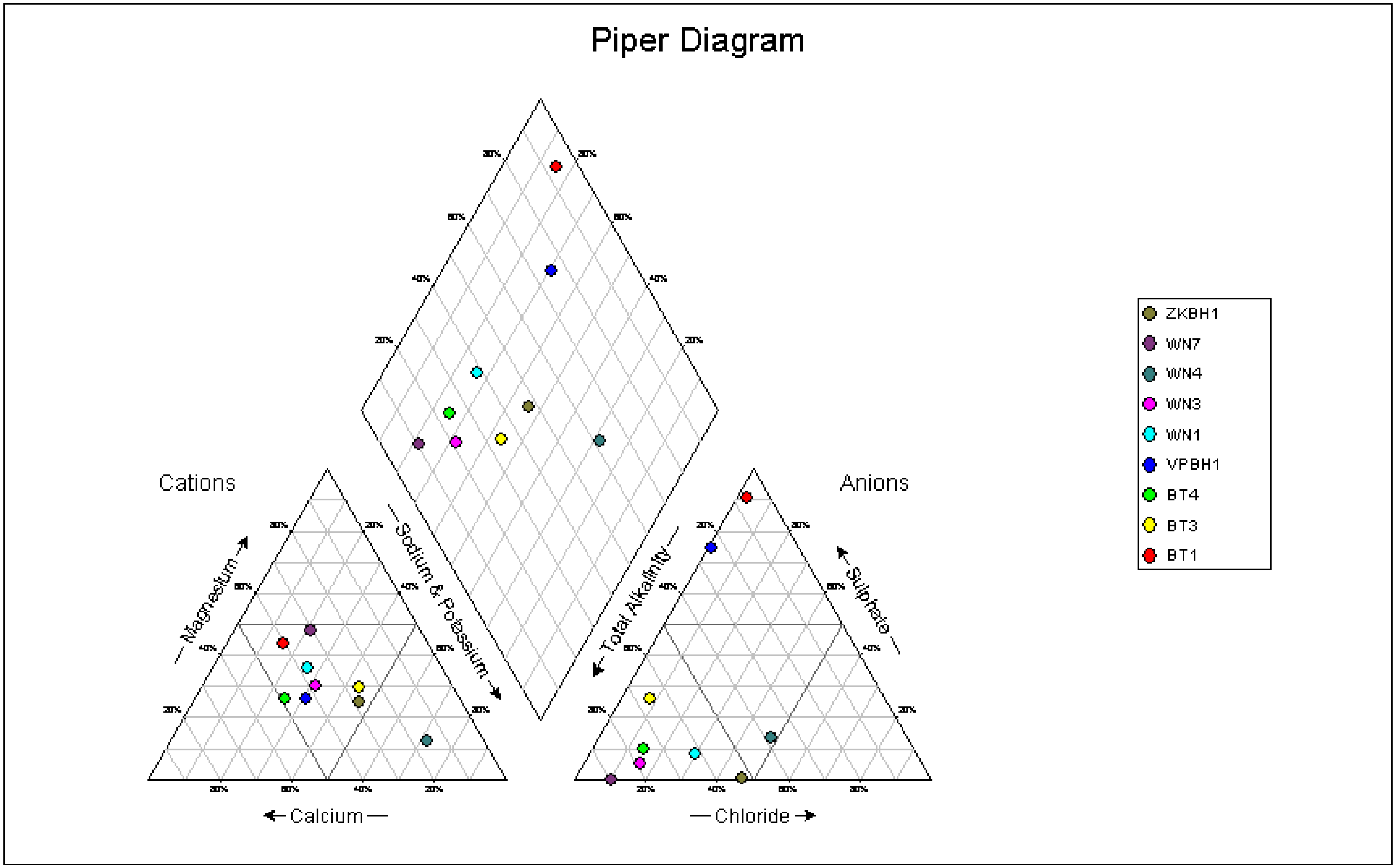


Figure 4: Piper Diagram from the groundwater samples taken during the hydrocensus study

Table 7: Water Quality analysis

Sample ID		Total Dissolved Solids	Nitrate NO_3 as N	Chlorides as Cl	Total Alkalinity as $CaCO_3$	Sulphate as SO_4	Calcium as Ca	Magnesium as Mg
Class 0	(Ideal)	<450	<6.0	<100	N/S	<200	<80	<30
Class I	(Acceptable)	450-1000	6.0-10.0	100-200	N/S	200-400	80-150	30-70
Class II	(Max. Allowable)	1000-2400	>10-20	>200-600	N/S	>400-600	>150-300	>70-100
Class III	(Exceeding)	>2400	>20	>600	N/S	>600	>300	>100
BT1	3	260	0.3	4	0	165	25.8	16.9
BT3	1	62	0.3	3	34	13	4.96	3.39
BT4	1	128	0.72	11	82	10.4	19.5	6.40
WN1	1	128	0.9	22	65	8.5	14.3	8.31
WN3	1	44	0.51	4	28	1.8	5.45	2.65
WN4	1	62	2.1	17	19	6.4	3.02	1.45
WN7	1	60	1.1	4	49	<1.0	6.49	6.15

Sample ID		Sodium as Na	Potassium as K	Iron as Fe	Manganese as Mn	Conductivity at 25° C in mS/m	pH-Value at 25° C	Aluminium as Al	Free and Saline Ammonia as N
Class 0	(Ideal)	<100	<25	<0.01	<0.05	<70	6.0-9.0	<0.15	N/S
Class I	(Acceptable)	100-200	25-50	0.01-0.2	0.05-1.0	70-150	5-6 or 9.0-9.5	0.15-0.3	N/S
Class II	(Max. Allowable)	200-400	50-100	>0.2-2	>0.1-1	>150-370	4-5 or 9.5-10	>0.3-0.58	N/S
Class III	(Exceeding)	>400	>100	>2	>1	>370	<4 or >10	>0.58	N/S
BT1	3	8.70	4.84	0.04	0.59	41.1	3.62	0.02	1.50
BT3	1	5.72	6.53	<0.01	0.06	9.55	6.94	<0.01	0.87
BT4	1	10.6	1.91	<0.01	<0.01	19.66	7.71	<0.01	0.67
WN1	1	10.2	2.30	0.63	0.02	19.61	7.42	<0.01	1.8
WN3	1	4.25	1.73	<0.01	<0.01	7.25	6.87	<0.01	0.54
WN4	1	13.6	3.67	<0.01	0.12	10.28	5.76	<0.01	0.8
WN7	1	5.08	0.30	<0.01	<0.01	9.72	7.12	<0.01	0.5

Sample ID		Total Dissolved Solids	Nitrate NO_3 as N	Chlorides as Cl	Total Alkalinity as $CaCO_3$	Sulphate as SO_4	Calcium as Ca	Magnesium as Mg	Sodium as Na	Potassium as K	Iron as Fe	Manganese as Mn	Conductivity at 25° C in mS/m	pH-Value at 25° C	Aluminium as Al	Free and Saline Ammonia as N
Class 0	(Ideal)	<450	<6.0	<100	N/S	<200	<80	<30	<100	<25	<0.01	<0.05	<70	6.0-9.0	<0.15	N/S
Class I	(Acceptable)	450-1000	6.0-10.0	100-200	N/S	200-400	80-150	30-70	100-200	25-50	0.01-0.2	0.05-1.0	70-150	5-6 or 9.0-9.5	0.15-0.3	N/S
Class II	(Max. Allowable)	1000-2400	>10-20	>200-600	N/S	>400-600	>150-300	>70-100	200-400	50-100	>0.2-2	>0.1-1	>150-370	4-5 or 9.5-10	>0.3-0.58	N/S
Class III	(Exceeding)	>2400	>20	>600	N/S	>600	>300	>100	>400	>100	>2	>1	>370	<4 or >10	>0.58	N/S
ZPBH1	1	42.00	3.10	8.00	25.00	0.10	4.56	2.44	7.64	1.52	-1.00	2.44	9.07	6.73	-1.00	<0.01
VPBH1	6	1132.00	0.20	7.00	199.00	587.00	129.00	47.60	96.30	17.20	-1.00	47.60	127.00	7.57	-1.00	<0.01

Red Highlighted results = not within SANS 241 - 2005 target water range for drinking water standards

4.9.2 Groundwater hydro-chemical footprint

The groundwater hydro-chemical footprint (Figure 5) in terms of TDS indicate the only elevated levels were measured at VPBH 1 which is at the historical mine workings on Vogelstruispoort and further down gradient from that at BT 1, which is likely a receptor to groundwater pollution from the old Vogelstruispoort workings.

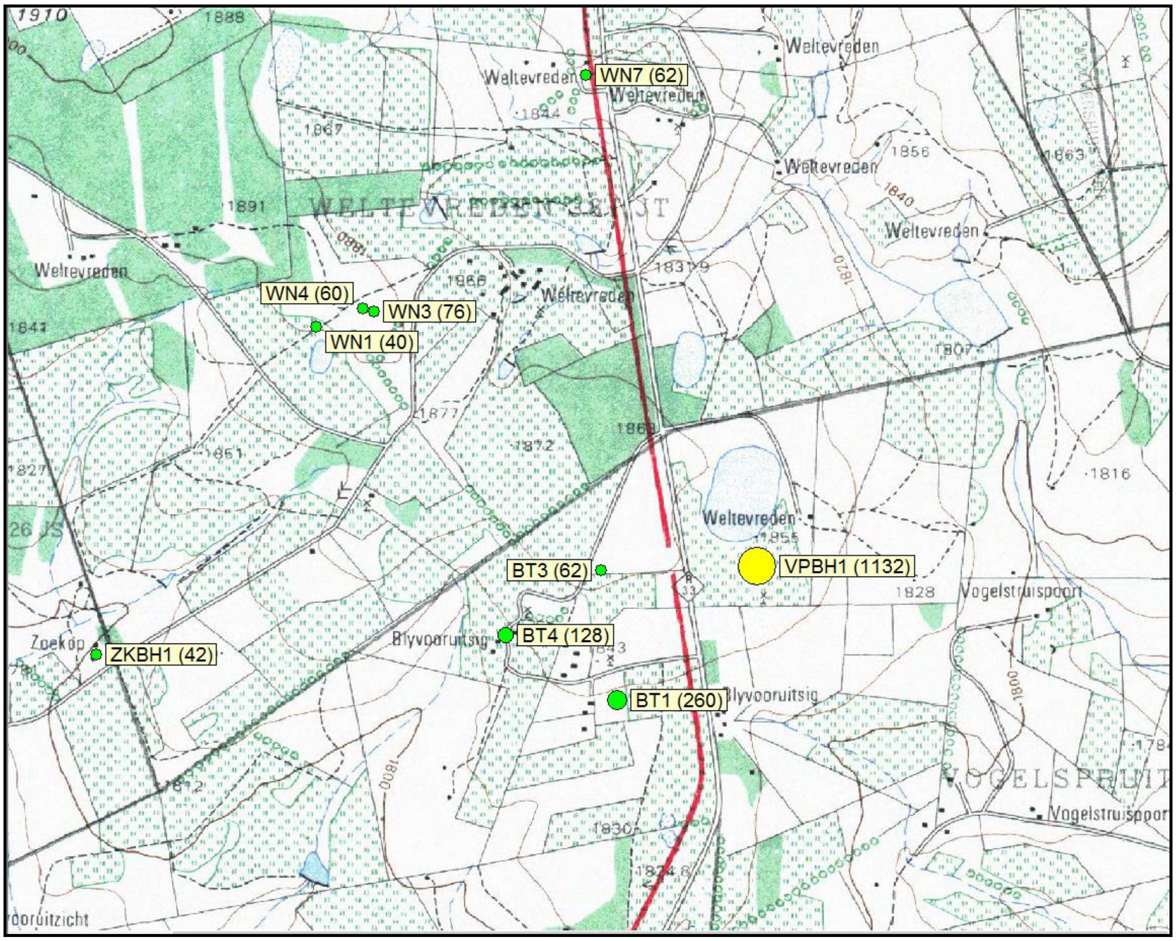


Figure 5: Groundwater hydro-chemical footprint (TDS mg/l)

4.10 Groundwater use

Data gathered during the field identified 10 boreholes within a 2 km radius from the project boundary of which 3 boreholes are used for domestic and livestock watering, 4 for domestic purposes only, 2 for livestock watering and 1 were not in use.

5 ACID BASE ACCOUNTING

Coal deposition is associated with pyrite being formed as the stratum is deposited in a reducing atmosphere. Mining activity will expose the pyrite to oxidising agents such as oxygen and ferric iron. The oxidation processes are as follows (Loos et al, 2000):

- $2FeS_2 + 2H_2O+7O_2 \rightarrow 2FeSO_4 + 2H_2SO_4$ (A)

  (pH >4.5)

- $4FeSO_4 + O_2 + 2H_2SO_4 \rightarrow 2Fe(SO_4)^3 + 2H_2O$ (B)

  (abiotic at pH>4.5; biotic at pH<2.5)

- $Fe_2(SO_4)^3 + 6H_2O \rightarrow 2Fe(OH)^3 + 3H_2SO_4$ (C)

  (pH > 2.5)

- $FeS + 14 Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$ (D)

The above equations lead to the formation of acidic conditions and the subsequent water quality deterioration due to heavy metal transport and salt loading, as the buffering capacity of the natural rock is utilised. Process (A) is an abiotic process occurring at a pH >4.5 due to spontaneous oxidation of the pyrite. Process (B) is the transformation of ferrous sulphate to ferric sulphate. This is an abiotic process when pH>4.5, but slows down and becomes biotic at pH < 4.5. At a pH below 2.5 the biotic process is most prominent. Process (C) produces ferric hydroxide (yellow boy), and further lowers the acidity. The abiotic process (D) then leads to the oxidation of the pyrite with the ferric iron product of process (B).

Process (B) is the rate limiting process in this mechanism. This process requires oxygen, therefore, the prevention of oxygen ingress and the creation of reducing conditions within the workings is crucial to slow down the oxidation of pyrite and the resulting low pH conditions.

Acid Base Accounting (ABA) include the neutralising potential (NP) of the formations will buffer the mine water and in cases where the NP significantly exceeds the acid potential (AP) this will lead to an increase in dissolved salts and neutral water quality. Acidic conditions with high salt loading are possible where the buffering capacity is insufficient or the reaction rated for neutralising are such that they cannot neutralise the acid generated.

The generation of poor quality water from mine workings is characterised by low pH, high heavy metal content and high salts or a neutral pH and high salt content. Acidic mine water rich in heavy metals is termed Acid Mine Drainage (AMD).

5.1 ABA results at Weltevreden Colliery

Geological samples were not collected from the drilling programme at Weltevreden during the exploration phase for ABA. However, specific boreholes were drilled during the late stages of the EIA/EMP process to determine the AP or NP of the overburden.

Geological core samples were send to SGS Lakefield laboratories in Johannesburg during August 2009 for ABA static testing and the results were received during the review phase of the EIA, however the results is included in section 5.1.1. and laboratory certificates are attached in Appendix B.

Core samples were also analysed by INNOV-X AFRICA specialising in X-ray fluorescence (XRF) technologies to investigate the concentration of sulphur within the overburden. It should be noted that this is only to obtain an approximate idea of the AP of the host rock and all results will have to be verified once the ABA testing have been completed.

XRF is a spectroscopic method that is commonly used for solids in which secondary X-ray emission is generated by excitation of a sample with X-rays. The X-rays eject inner-shell electrons and outer-shell electrons take their place and emit photons in the process. The wavelength of the photons depends on the energy difference between the outer-shell and inner-shell electron orbital. Limits of Detection (LOD) are measured in parts per million (ppm). Actual limits of detection depend upon specific sample types, and presence of interfering elements within the sample.

The results from the XRF analysis concluded that only three of the lithologies had sulphur levels above the LOD that might have a high AGP. The results from the XRF analysis are presented in Table 8.

Table 8: XRF results from the two core boreholes drilled for ABA testing

Reading	Lithology	Sulphur (ppm)	Calcium (ppm)	Manganese (ppm)	Iron (ppm)
Borehole 1					
1	Laterite	<LOD	516	63	6376
2	Mudstone	<LOD	859	54	5343
3	Mudstone	<LOD	853	63	68458
4	Banded Shale	<LOD	757	147	4134
5	Banded Shale	<LOD	2438	2651	4369
6	Banded Shale	<LOD	1540	1084	20130
7	Banded Shale	<LOD	1914	900	106662
8	Banded Shale	<LOD	873	222	79578
9	Banded Shale	<LOD	1552	476	64358
10	Vitrinitic coal	10689	909	39	25349
11	Sandstone	<LOD	914	40	47964
12	Sandstone	4081	2273	378	7322
23	Sandstone	<LOD	2592	86	3120
14	Banded sandstone	<LOD	4346	719	31440
15	Banded sandstone	<LOD	2006	1030	4229
16	No 2 Coal seam	<LOD	59840	255	56378
17	No 2 Coal seam	<LOD	29074	168	43961
Borehole 2					
18	Sandstone	<LOD	529	<LOD	266
19	Sandstone	<LOD	<LOD	41	5127
20	Sandstone	<LOD	494	<LOD	1145
21	Mudstone	<LOD	<LOD	232	120845
22	Sandstone	<LOD	780	63	3325

Reading	Lithology	Sulphur (ppm)	Calcium (ppm)	Manganese (ppm)	Iron (ppm)
23	Shale	<LOD	920	58	7960
24	Banded sandstone	<LOD	1982	1615	51827
25	Banded sandstone	<LOD	3279	3189	92948
26	Banded sandstone	<LOD	<LOD	76	2395
27	No 2 Coal seam	4782	1149	92	10265
28	No 2 Coal seam	<LOD	925	35	1159

* parts per million (ppm)

5.1.1 Acid Potential Measurements

The main advantages of static tests are that they are quick to perform and quantitative results on acid, base and leaching parameters are obtained.

In addition to pH measurements, the actual acid and base potential of the surrounding host rock has been determined. These results are presented in Table 10, 11 and 12.

Table 9: **Modified Acid Base Accounting criteria for interpretation**

TYPE I	Potentially Acid Forming(Strong AGP)	Sulphide > 0.3%, negative net NP (< -20), NP/AP ratio <1
TYPE II	Intermediate (Medium AGP)	Sulphide > 0.2 %, Negative net NP (> - 20),NP/AP ratio <1
TYPE III	Non-Acid Forming(Low AGP)	Sulphide < 0.3 %,Low NP, Negative net NP ,NP/AP ratio <1
TYPE IV	Uncertain (Possible AGP or NP)	Low AP, Low NP, NP/AP RATIO BETWEEN 1&3
TYPE V	Low NP	Sulphide < 0.1%, Low NP

TYPE VI	Medium NP	Sulphide <0.5%, Positive net NP(> 10), NP/AP ratio > 3
TYPE VII	Strong NP	Strongly positive net NP(>20), NP/AP ratio > 4, High Carbonate

The formation of a soluble mineral phase such as sodium carbonate in this environment is likely. However, it cannot be disputed that the Modified ABA results show a low AGP to acidify the seepage emanating from the mine over a relatively short period. Indications from these results show that the banded sandstones will have a medium NP with the banded shales and No. 2 coal seam having a low AGP.

It should be understood that the modified ABA test method only provide an indication of the potential for acid generation. The lithological profiles at Weltevreden suggest that these rocks have the potential to produce an acidifying effluent over the long-term.

Table 10*: Modified Acid Base Accounting test results for Weltevreden*

Acid Generation Potential (AGP) & Neutralization Potential(NP)	Sample Identifiers	General reasons for classification (with some exceptions)
Low AGP	0603; 0605; 0606; 0607	Sulphide < 0.3 %,Low NP, Negative net NP ,NP/AP ratio <1
Medium NP	0602; 0604	Sulphide > 0.3%, negative net NP (< -20), NP/AP ratio <1

Table 11: Static Acid Rock Drainage Test Report for Weltevreden

Sample ID	**0602**	**0603**	**0604**	**0605**	**0607**	**0607**
Fizz Rating	1	1	1	1	1	1
Paste pH	6.8	6.7	7.1	7.0	6.8	7.7
Sample Weight(g)	2.00	1.98	1.98	1.98	1.98	2.00
Normality HCl (N)	0.108	0.108	0.108	0.108	0.108	0.108
Total HCl added (ml)	35.2	20.0	39.3	20.0	31.0	20.0
Normality NaOH (N)	0.100	0.100	0.100	0.100	0.100	0.100
Total NaOH added (ml)	32.5	19.7	34.0	18.7	29.8	20.5
NP	13.8	4.8	21.3	7.3	9.3	2.7
AP	0.63	1.56	0.31	1.56	0.31	0.31 0.
Net NP	13.2	3.2	21.0	5.8	9.0	2.4
NP/AP	22.1	3.1	68.2	4.7	29.7	8.8
Total S(%)	0.09	0.07	0.09	0.07	0.05	<0.01
Sulphide S (%)	0.02	0.05	0.01	0.05	<0.01	<0.01
SO_4 (%)	0.20	0.05	0.25	0.06	0.13	<0.03
CO_3 (%)	0.19	0.19	0.36	<0.05	0.30	<0.05

Northern Coal submitted coal samples from the No. 2 seam to Midlab CC. in Middelburg during 2008 for analysis. It was found that there is a tendency of quality differences regarding the upper, middle and lower portions of the seam in individual intersections. However, this tendency could not be confirmed over the entire area. The quality of the total No.2 coal seam is summarised in Table 12.

The yield of the prime coal demonstrates potential around the centre of the prospecting area and yields of up to 34.9 % were analysed with a mean of approximately 25%. The middling coal was analysed with a mean of approximately 55 % for the same area.

Table 12: Summary of the total No. 2 Seam Coal Characteristics (Air dried)

RD	Yield %	CV MJ/kg	Ash %	Volatiles %	Fixed Carbon %	Sulphur %
Raw	96.7	15.69	42.27	17.99	36.89	2.81

Several factors calculated in ABA by Soregaroli and Lawrence (1998) indicated that for sustainable long-term acid generation, at least 0.3% sulphide-S is needed. Values lower than 0.3% can yield acidy but it is only of short-term significance. From the results calculated in the above table it can be seen that the number 2 coal seam at Weltevreden theoretically have a high AGP. This however did not correlate with the finding from the static rock testing that indicated that the No. 2 coal seam had a low AGP.

It must be taken into consideration that the No. 2 coal seam will be mined out and only a small percentage of coal will remain within the open cast pit.

5.2 Old Vogelstruispoort Colliery ABA results

Soil samples were collected during the environmental assessment of the old Vogelstruispoort Colliery (Plan 3). The colliery is located in close proximity of the planned mining area. Affected landowners requested that further studies be undertaken to assess the extent of environmental degradation at Vogelstruispoort. The soil samples were sent to SGS laboratory in Johannesburg for past and static acid rock drainage testing.

The main advantages of static tests are that they are quick to perform while quantitative results on acid, base and leaching parameters are obtained. The ABA criteria for interpretation can be seen in Table 13.

Table 13: Modified Acid Base Accounting criteria for interpretation

TYPE I	Potentially Acid Forming (Strong AGP)	Sulphide > 0.3%, negative net NP (< -20), NP/AP ratio <1
TYPE II	Intermediate (Medium AGP)	Sulphide > 0.2 %, Negative net NP (> -20),NP/AP ratio <1
TYPE III	Non-Acid Forming (Low AGP)	Sulphide < 0.3 %,Low NP, Negative net NP ,NP/AP ratio <1
TYPE IV	Uncertain (Possible AGP or NP)	Low AP, Low NP, NP/AP RATIO BETWEEN 1&3
TYPE V	Low NP	Sulphide < 0.1%, Low NP
TYPE VI	Medium NP	Sulphide <0.5%, Positive net NP(> 10), NP/AP ratio > 3
TYPE VII	Strong NP	Strongly positive net NP(>20), NP/AP ratio > 4, High Carbonate

The following results were obtained from the ABA testing (Table 14-Table 15). It can be seen that sample VPSS1 and sample VPSS3 indicate a low potential for acid generation. Sample VPSS2 show an uncertain potential for both acid generation and neutralisation potential.

Table 14: Samples analysed according to these broad categories

Acid Generation Potential (AGP)	**Sample ID**	**General reason for classification (with some exceptions)**
Low AGP	VPSS1 and VPSS3	Sulphide > 0.3%, negative net NP (< -20), NP/AP ratio <1
Uncertain possible AGP or NP	VPSS2	

* The NP on these samples may be underestimated due to possible stored acidity, as indicated by a paste pH value of less than 5.5.

Table 15: ABA results – Test method EPA ABA (Lawrence)

Sample ID	**VPSS1**	**VPSS1**	**VPSS1**
Fizz Rating	1	1	1
Paste pH	4.3	4.4	6.0
Sample Weight(g)	2.01	2.00	1.98
Normality HCl (N)	0.112	0.112	0.112
Total HCl added (ml)	20.0	20.0	20.0
Normality NaOH (N)	0.101	0.101	0.101
Total NaOH added (ml)	24.1	19.7	21.9
NP	-4.8	6.3	0.7
AP	2.50	4.38	2.19
Net NP	-7	1.9	-1.5
NP/AP	-1.9	1.4	0.3
Total S (%)	0.08	0.14	0.07
Sulphide S (%)	0.52	0.19	1.48
SO_4 (%)	1.32	0.15	4.21
CO_3 (%)	0.25	0.08	<0.05

6 GROUNDWATER IMPACTS

The following major groundwater impacts are expected during the life of mine:

- **Dewatering** (water users in close proximity or downstream user): Analytical solutions and readily available groundwater data of the Witbank coalfields were used to calculate the possible drawdown after one year of opencast mining. The result of this is indicative and might vary slightly in reality. A radius of influence of approximately 500 m was derived from this method using generic existing hydraulic conductivity and storativity values. This could have associated impacts on existing adjacent water users.
- **Acid mine drainage** (risk ABA): Studies undertaken by Northern Coal indicated that the No. 2 coal seam could have a high acid generating potential. Geological core from the coal seam, interburden and overburden have been tested for acid base accounting and neutralisation potential. Results indicated that a low acid generating potential can be expected from the No. 2 coal seam and host rock. The banded sandstone indicated to have a medium neutralisation potential that will help neutralise the acid generation.
- **Post mining water management** (flooding decanting and downstream impacts): High recharge values are expected through the back-filled areas and high hydraulic conductivity values can be expected from the spoils and waste rock. Surface and coal seam elevations indicate three possible decant points on site thus appropriate mitigation measures will have to be put in place to manage the water after mine closure. AMD could impact on the water quality while potentially negatively impacting on receiving water users. More in depth studies will have to be performed during the operational phase to determine the geochemical characteristics of the groundwater during and after mining has taken place.

7 GROUNDWATER IMPACT ASSESSMENT

The impact assessment was performed based on the available geological, geohydrological and mining information. The following sections describe the expected impacts to groundwater at the Weltevreden Coal Mining Project.

7.1 Construction phase

7.1.1 Groundwater quality

The operation of the fuel and lubricants storage facility has the potential for causing contamination of surface water due to infrastructure failure (emergency), leakage or spillages during normal operation. Included in normal operation is the potential for the incorrect disposal of spill absorbing material.

The operation of offices, ablutions and maintenance workshops has the potential for the contamination of groundwater due to incorrect disposal of domestic and hazardous wastes, incorrect handling of workshop effluent, spills and leaks.

The use of nitrate-based explosives during blasting for the establishment of the opencast areas has the potential to cause surface water pollution due to the addition of nitrates to water.

7.1.2 Groundwater quantity

The establishment of hard paved areas during infrastructure construction and haul road construction reduces the recharge of aquifers due to increased runoff.

The establishment of the opencast areas is expected to have a negative effect on the surrounding aquifers within the immediate area which can cause lowering of water levels on neighbouring boreholes.

7.2 Operational phase

The local aquifer systems are classified as minor aquifer systems and the regional utilisation thereof coincides with the principle land uses of grazing and to provide domestic water supply. The changes induced by mining may lead to a dewatering cone in the immediate vicinity of the mine, an increase in recharge, storage capacity (opencast workings) and deterioration in water quality.

7.2.1 Groundwater quality

The spillage of ammonium nitrate based explosives during charging of holes, misfires and incomplete combustion of explosives may lead to an increase in nitrate levels in groundwater.

The operation of the fuel and lubricants storage facility has the potential for causing contamination of groundwater due to either an infrastructure failure (emergency) or spillages during normal operation. Included in normal operation is the potential for the incorrect disposal of spill absorbing material.

AMD formation from spoil piles, exposed shale and backfilled spoils and discard in rehabilitated areas will affect groundwater quality through the acidification of groundwater and the leaching of salts and heavy metals from rock. Depending on the buffering capacity of the host rock, AMD will either result in the formation of low pH, high dissolved salt and heavy metal content water (insufficient buffering capacity) or the formation of neutral pH, high salt (including sodium) water, if high buffering capacity exists.

Polluted groundwater generated in the opencast areas are not connected to any underground mining areas and will not form part of the inter mine flow.

7.2.2 Groundwater quantity

The establishment of hard paved areas during infrastructure construction and haul road construction reduces the recharge of aquifers due to increased runoff.

The removal of vegetation during topsoil and overburden pre-stripping for haul road construction reduces the recharge of rain water to aquifers due to increased run-off.

Mining of the opencast areas has the effect of dewatering adjacent aquifers or lowering the water table.

7.3 Decommissioning phase

The quality of groundwater will be impacted upon by mining. The mining area might produce a seepage zone or decant as the recharge to opencast workings have increased by the disturbance of the strata. There are no large scale groundwater users in the area but poor quality groundwater emerging as seeps into the surface water environment can be seen as a negative, long term impact.

7.3.1 Groundwater quality

The long term water quality impact for coal mining is the generation of AMD water.

Opencast pits must be rehabilitated in such a way that recharge to the backfilled pit areas are limited to an absolute minimum. This would include shaping to allow surface water to drain away from the opencast pit areas, compaction of materials, suitable soil cover and vegetation of the rehabilitated areas to intercept recharge.

7.3.2 Groundwater quantity

In the opencast areas water levels will rise until the decant level is reached. Water quality in the opencast pits is not expected to be suitable for use and these areas will be sterilised in terms of available groundwater quantity.

7.4 Cumulative impacts

The cumulative impacts due to the proposed mining could be of a quantitative and qualitative nature. The aquifers within the region are classified as minor aquifer systems and their main function is a domestic water supply source as well as supplying base flow to the surface water environment. This will result in a positive impact locally and could see the importance of groundwater increasing as a potential source within the catchment. However, the water quality within the workings could be good or deteriorate depending on the geochemical characteristics of the material. This could in turn result in surface water users being put under pressure should the decant water quality lead to the deterioration of surface water resources in the catchment. The cumulative impact on the catchment will have to be taken into account for mining, agriculture and the remainder of the current surface and groundwater uses in the Komati River Catchment.

8 GROUNDWATER MANAGEMENT

Since this will be an opencast operation only, the following management options should be considered during the Mine life.

8.1 Opencast mining

Water management measures during the operational phase should include:

Clean water management

Clean water runoff should be separated from the pit and waste rock dump areas by means of berms constructed up gradient of the mining infrastructure. The clean water will drain naturally into the environment.

Dirty water management

Dirty water pumped from the pit should be discharged into a PCD and/or recycled in the mining operations.

Storm water management

Storm water controls around the opencast pits should include:

- Design and construct storm water drainage channels to be able to handle 1:50yr rainfall event or more to ensure sufficient capacity for carrying storm waters around and away from the pit; and
- Construct berms upstream of the opencast pit areas to ensure flood water does not enter the pit.

Decommissioning

Groundwater management associates with rehabilitation activities could include the rehabilitation of spoils. The aim of this is to control the rate and migration of acid generation. Techniques to be followed include levelling, top soiling with a mixture of clay and coarser material as a growth medium and re-vegetation.

An alternative management practice is selective spoil handling for example:

Scenario
Significant volume of the spoil is flooded
Weathered spoil
Spoil with high base potential
Spoil with high acid potential

The advantages of spoil handling include:

- Acidic conditions in the spoil water may be eliminated;
- Heavy metals are precipitated within the spoil;
- The net salt load of the system is reduced; and

- Weathered materials inhibit the pyrite oxidation by reducing the influx of oxygen to the reactive surface.

The introduction of buffering agents such as lime or power station fly ash can also be used to improve the pH in the groundwater quality, but it could become expensive and not viable after closure.

9 MONITORING

Groundwater management strategies for most mining and industrial activities are limited and emphasis falls on prevention of pollution rather than the treatment thereof. Early detection of contamination is the key to react and manage any possible sources of pollution effectively. This will assist in identifying potential future impacts from mining operations on the groundwater environments.

9.1 Water Level

Groundwater levels must be recorded on quarterly basis using an electrical contact tape or pressure transducer, to detect any changes or trends in groundwater flow direction.

9.2 Sampling Method and Preservation

When sampling boreholes the following procedures should be followed:

- One litre plastic bottles, with a plastic cap and no liner within the cap are required for most sampling exercises. Glass bottles are required if organic constituents are to be tested for. Sample bottles should be marked clearly with the borehole name, date of sampling, water level depth and the sampler's name;
- Water levels (m mbgl) should be measured prior to taking the sample, using a dip meter;
- Each borehole to be sampled should be purged (to ensure sampling of the aquifer and not stagnant water in the casing) using a submersible pump or in the event of a small diameter borehole, a clean disposable polyethylene bailer. At least three borehole volumes of water should be removed through purging; or through continuous water quality monitoring, until the electrical conductivity value stabilizes;

- Metal samples must be filtered in the field to remove clay suspensions;
- Samples should be kept cool in a cooler box in the field and kept cool prior to being submitted to the laboratory; and
- The pH and EC meter used for field measurements should be calibrated daily using standard solutions obtained from the instrument supplier.

The constituents to be analysed for is listed in Table 16.

Table 16: Monitoring sampling analysis

Physical	**Cations**	**Anions**	**Metals**
pH	Calcium (Ca)	Chloride (Cl)	Aluminium (Al)
Electrical conductivity (EC)	Magnesium (Mg)	Sulphate (SO_4)	Antimony (Sb)
Total dissolved solids (TDS)	Sodium (Na)	Nitrate (NO_3–N)	Iron (Fe)
Suspended solids (SS)	Potassium (K)	Phosphate (PO_4-P)	Lead (Pb)
Total Alkalinity		Fluoride (F)	Manganese (Mn)
Ca-Mg-Hardness			Zinc (Zn)

9.3 Monitoring Frequency

Groundwater is a slow-moving medium and drastic changes in the groundwater composition are not normally encountered within days. Groundwater monitoring should be conducted quarterly.

Samples should be collected by an independent groundwater consultant, using best practice guidelines and should be analysed by a SANAS accredited laboratory.

Groundwater levels must be recorded on a quarterly basis to within an accuracy of 0.1m using an electrical contact tape, float mechanism or pressure transducer, to detect any changes or trends in groundwater levels.

9.4 Sampling Locations

The main objectives in positioning the monitoring boreholes are to:

- Monitoring of groundwater migrating away from the pit area; and
- Monitoring the lowering of the water table and the radius of influence.

The following points should be included in the groundwater monitoring network:

- ZKBH1;
- WN 3;
- BT 4; and
- BT 6.

Additional borehole monitoring points could be selected and/or drilled during the construction phase if required.

9.5 Data management

In any project, good hydrogeological decisions require good information developed from raw data. The production of good, relevant and timely information is the key to achieve qualified long-term and short-term plans. For the minimisation of groundwater contamination it is necessary to utilize all relevant groundwater data.

Digby Wells has compiled and Excel-based database during the course of this investigation and it is recommended that Northern Coal utilises this database and continuously update and manage it as new data becomes available.

Monitoring results will be captured in an electronic database as soon as results become available allowing:

- Data presentation in tabular format;
- Time-series graphs with comparison abilities;
- Graphical presentation of statistics;

- Presentation of data, statistics and performance on diagrams and maps; and
- Comparison and compliance to legal and best practice water quality standards.

9.6 Reporting

Based on the recorded water quality data, the data management functions as described in Section 9.4 will be carried out and reported to mine management on a monthly basis. The contents of the report should include the monthly water monitoring results and trends at surface points, as well as comments on the effectiveness of the mitigation measures and monitoring program.

Reporting to the authorities, should be as specified in the permitting/licensing conditions.

Any accidental release of pollutants or possible polluting substances should be reported to the relevant authorities as specified in the permitting conditions.

10 CONCLUSION AND RECOMMENDATIONS

The following conclusions are evident from the geohydrological evaluation of the Weltevreden area:

- Current land use practises are restricted to agricultural activities, which include livestock and small scale maize production;
- Groundwater use in the immediate vicinity of Weltevreden, from both boreholes and springs, is limited to domestic use and livestock watering;
- Borehole yields from the aquifers are low and no major groundwater development is expected;
- Water levels are generally shallow and follow the surface topography. Therefore, groundwater will flow from highest to lowest elevation, in the direction of surface water drainage;
- Water quality is generally of a good drinking water quality with only one sample (BT1) being outside the South African National Standard for drinking water; and
- ABA suggests possible low acid generating potential can be expected from the No. 2 coal seam and host rock.

The following recommendations are made:

- Groundwater management measures proposed should include the rehabilitation of spoils, and/or selective spoil handling and/or the introduction of buffering agents and
- Regular groundwater monitoring should commence at the start of the constructions phase as proposed under Heading 9 of this report.

11 REFERENCES

Department of Water Affairs and Forestry. 1998. *Minimum requirements for water monitoring at waste management facilities*, Pretoria.

Department of Water Affairs and Forestry. 2008. *Mpumalanga Groundwater Master Plan,* Pretoria.

EMAKHAZENI LOCAL MUNICIPALITY (ELM), 2006: *Environmental Management Framework (EMF).* Strategic Environmental Focus (Pty) Ltd 4 3 Third Draft – 10 October 2007.

Grobbelaar R. Usher B. Cruywagen L-M. De Necker E. Hodgson F.D.I. 2004. *Long-term Impact of Intermine Flow from Collieries in the Mpumalanga Coal Fields*. WRC Report no. 1056/1/2004.

Hodgson F.D.I. Lucas E. 2006. *Interim Report on Mine Water Balances in Intermine Flow for Ingwe Collieries in Mpumalanga*. Report no. 2006/06/FDIH.

Hodgson F.D.I. Kranz R.M. 1998. *Groundwater Quality Deterioration in the Olifants River Catchment above Loskop Dam with Specialised Investigations in the Witbank Dam Sub-Catchment*. WRC Report no. 291/1/98.

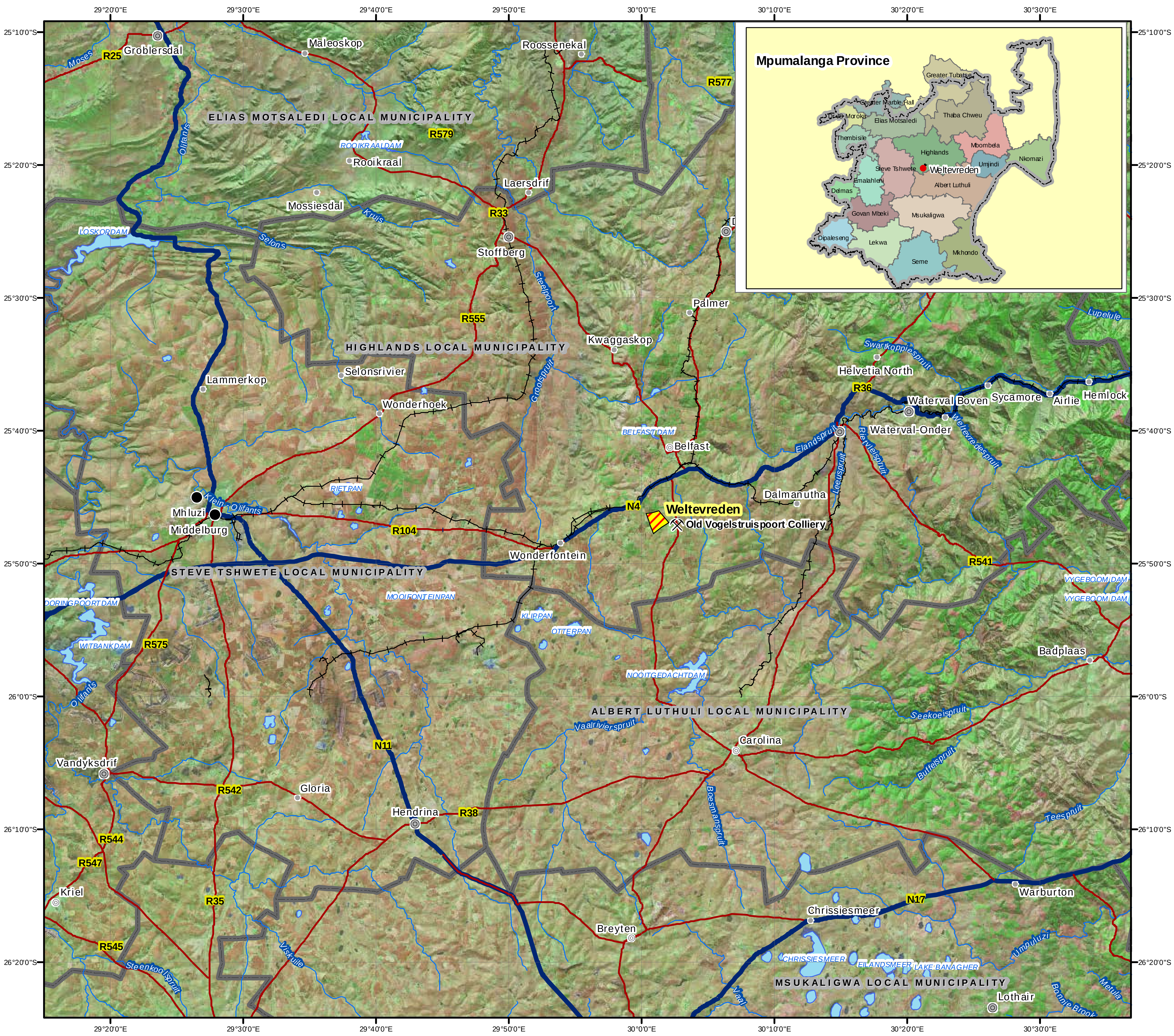
Nel, P.W.A, 2008. *Geology and Coal Characteristics on Portion 15 and 16 of Weltevreden 381 JT.* Northern Coal (Pty) Ltd.

Soregaroli, B.A. and Lawrence, R.W. (1998). *Update on Waste Characterization Studies, Proc. Mine Design, Operations and Closure Conference, Polson, Montana*

Vermeulen P.D. Hodgson F.D.I. 2005. *Recharge in South African Underground Collieries*. Biennial Groundwater Conference, Pretoria.

APPENDIX A

PLANS



Plan 1

Northern Coal Weltevreden

Regional Setting

Legend

- Capital City
- Major Town
- Other Town
- Secondary Town
- Settlement
- Rivers
- Railway Lines
- National Route
- Main Road
- Water Area
- Local Municipality Boundary
- Weltevreden Site

N

DWA

© Digby Wells & Associates June 2009

Projection: Transverse Mercator
Central Meridian: Lo31
Datum: WGS84

1:500,000

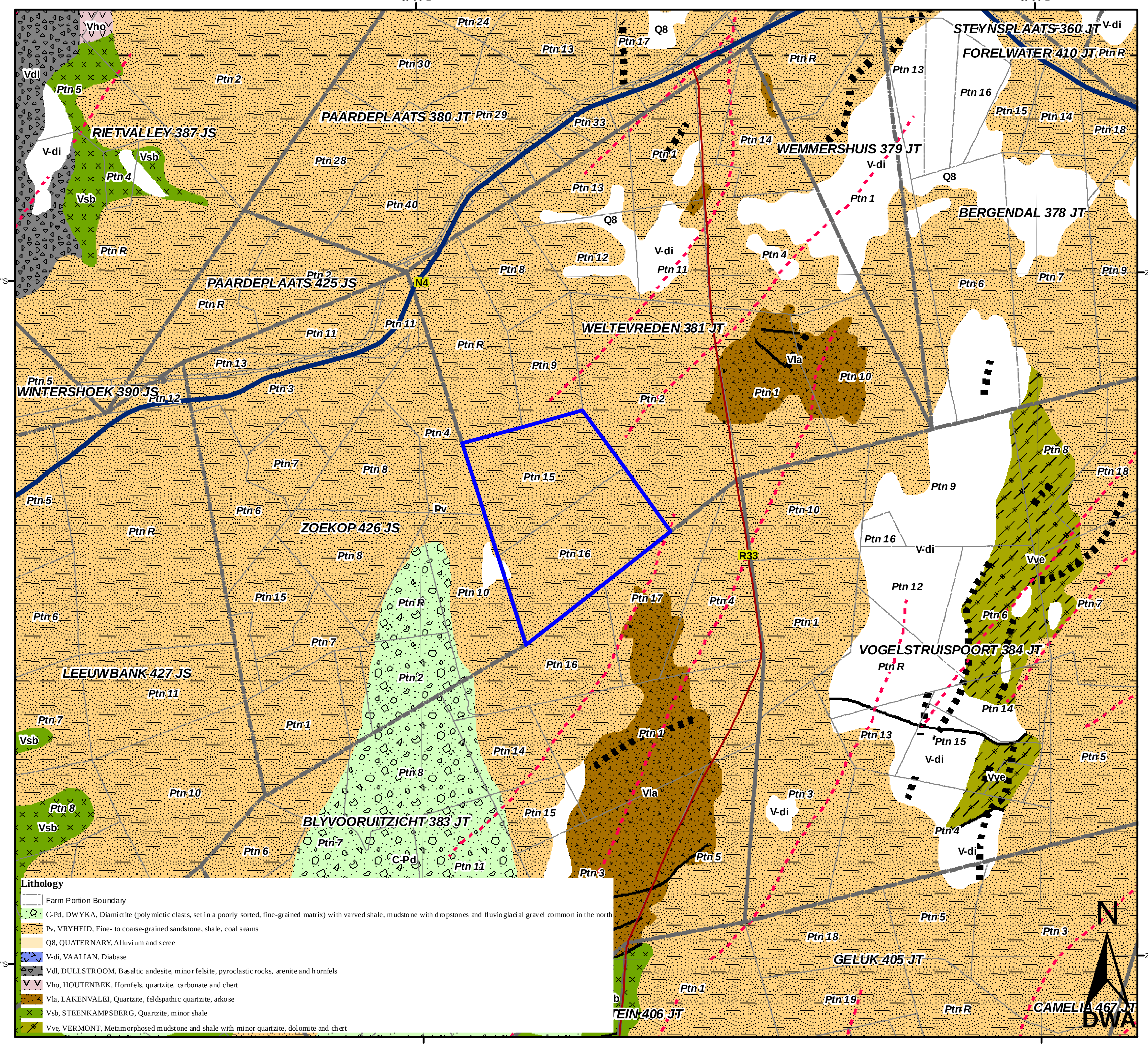
0 4.5 9 18 27 36
Kilometres

Ref:/bjt.NOR335.200804.084

Northern Coal Weltevreden

Geology

Plan 4



Legend

- National Route
- Main Road
- Lineament
- Fault
- Dyke
- Farm Portion Boundary
- Farms Boundary
- Weltevreden Site

(Source: South African Council for Geoscience)

Projection: Transverse Mercator
Central Meridian: Lo31
Datum: WGS84

1:50,000

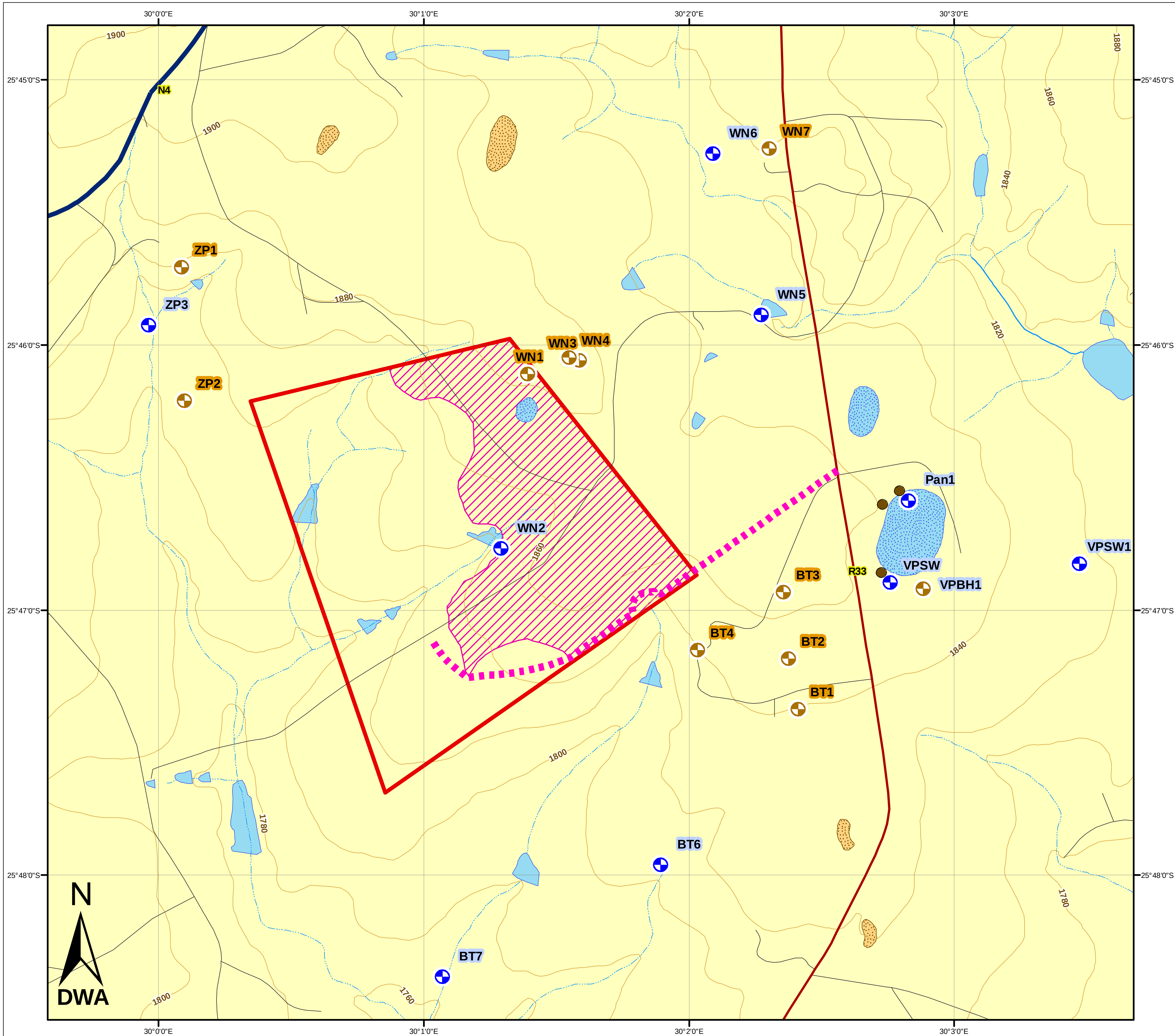
0 0.5 1 2 3 4
Kilometres

Ref:/bjt.NOR335.200804.085

Plan 3

Northern Coal Weltevreden

Hydrocensus



Legend

- Soil Sampling
- Borehole
- Surface water
- National Route
- Main Road
- Minor Road
- Proposed Haul Road
- Perennial Stream
- Non-Perennial Stream
- Contours 20m
- Proposed Open Cast Pit
- Weltevreden Site
- Dam
- Perennial Pan
- Non-Perennial Pan

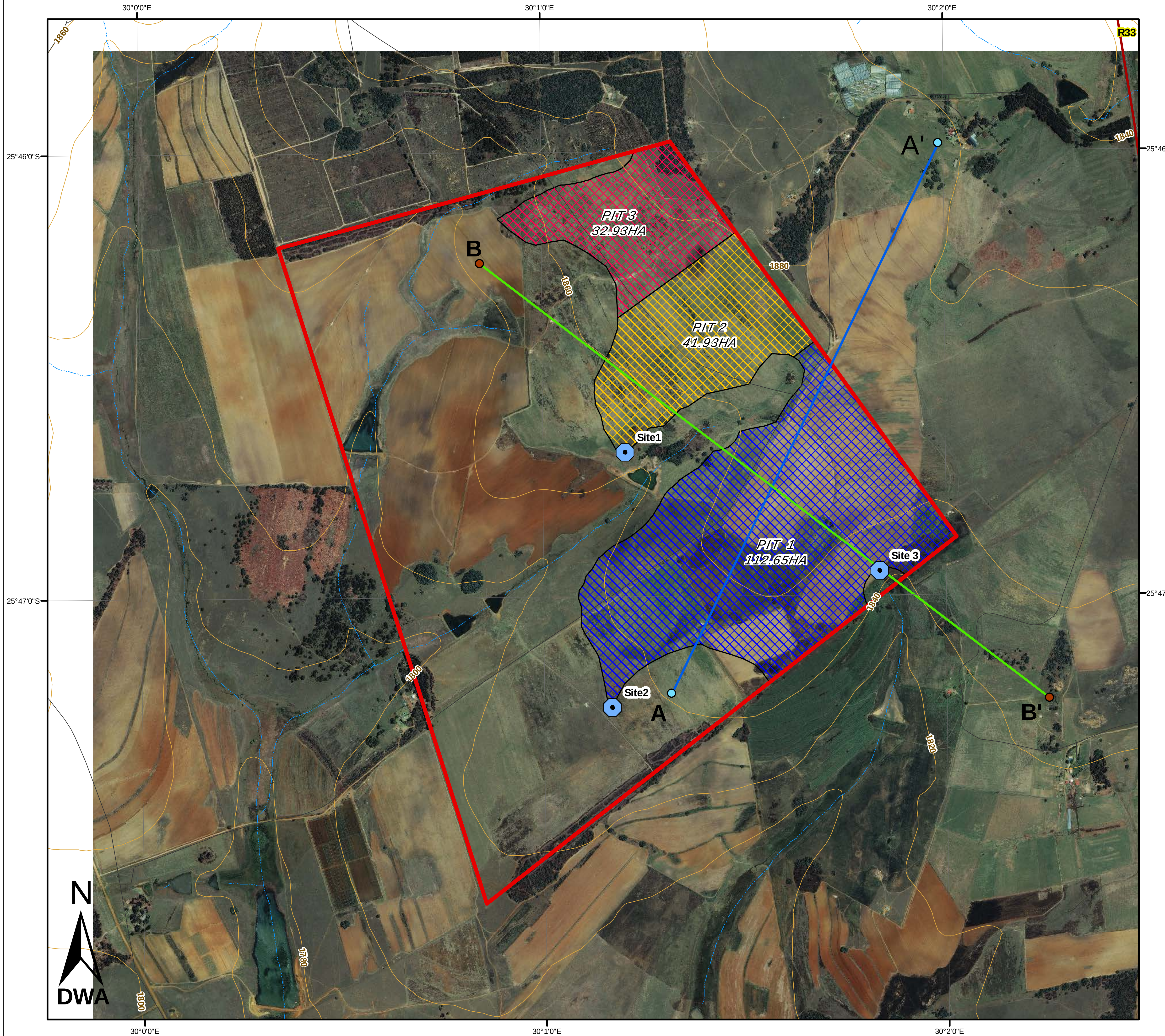
(2002 Ikonos Satellite Imagery)

Projection: Transverse Mercator
Central Meridian: Lo31
Datum: WGS84

1:25,000

0 0.25 0.5 1 1.5
Kilometres

Ref:/glo.NOR335.200906.0015



Plan 4

Northern Coal Weltevreden

Decant Points

Proposed Mine Infrastructure

- Decant Points
- Profile 1
- Profile 2
- Weltevreden Site

Proposed Open Cast Pits

- Pit 1
- Pit 2
- Pit 3

Topographical Features

- National Route
- Perennial Stream
- Main Road
- Non-Perennial Stream
- Minor Road
- Contours 20m

(2002 Ikonos Satellite Imagery)

Projection: Transverse Mercator
Central Meridian: Lo31
Datum: WGS84

1:15,000

0 0.125 0.25 0.5 0.75 1
Kilometres

Ref:/bjt.NOR335.200806.001

APPENDIX B

LABORATORY CERTIFICATES

The Modified ABA test results in a characterization of the material as either having a large potential to generate acidity, a potential for no acid generation or, if the results fall within a certain range, uncertainty with respect to net acid generation potential. While there are different approaches to the interpretation of Modified ABA tests, the net neutralising potential (NP-AP) is often used as a general indicator of the potential for acid generation and the ratio of NP/AP is also used as an interpretative guideline.

The following interpretation of the potential for acid generation is based on our review of the sulphur species concentrations, carbonate values, the AP, NP and net NP values and the NP/AP ratios. When considering this summary it is important to keep in mind that the Modified ABA test method provides an ***indication*** of the potential for acid generation. Whether or not acidic drainage will result is largely a function of the mineralogy, the availability of each acid generating and neutralising mineral present, the physical characteristics of the material and the environmental setting.

The following table groups the samples analysed according to these broad categories.

Acid Generation Potential (AGP)	Sample Identifiers	General reasons for classification (with some exceptions)
Strong AGP		Sulphide > 0.3% Negative net NP (< -20) NP/AP ratio <1
Medium AGP		Sulphide > 0.2% Negative net NP (> -20) NP/AP ratio <1
Low AGP		Sulphide < 0.3% Low NP Negative net NP NP/AP ratio <1
Uncertain possible AGP or NP		Low AP Low NP NP/AP ratio between 1 and 3
Low NP	0603; 0605; 0606; 0607	Sulphide < 0.1% Low NP
Medium NP	0602; 0604	Sulphide <0.5% Positive net NP (> 10) NP/AP ratio > 3
Strong NP		Strongly positive net NP (> 20) NP/AP ratio > 4 High carbonate

Senior Environmental Chemist

SGS South Africa (Pty) Ltd Reg. No: 1949/032643/07
PO Box 82582 Southdale 2135 58 Melvill Street Booysens Johannesburg 2091 South Africa
t +27(0)11 680 3466 f +27(0)11 433 3654 www.za.sgs.com
Member of the SGS Group (SGS SA)
Directors: H. Williams; D.R. Gartmann (Swiss); R.A. Markus (Dutch)

Static Acid Rock Drainage Test Report

Client Information

Project No.:	NOR 335	**Date Received:**	August 21, 2009
Company:	Digby Wells & Assoc.	**Quote/Proposal #:**	-
Client Contact:	Heinrich Schreuder	**Lab. Ref.:**	LA069201
Order Number:	-	**No. of Samples:**	6

Test Information

Test Method: **Modified EPA ABA (Lawrence)**

Sample ID:	0602	0603	0604	0605	0606	0607
Fizz Rating:	1	1	1	1	1	1
Paste pH:	6.8	6.7	7.1	7.0	6.8	7.7
Sample Weight (g):	2.00	1.98	1.98	1.98	1.98	2.00
Normality HCl (N):	0.108	0.108	0.108	0.108	0.108	0.108
Total HCl added (ml):	35.2	20.0	39.3	20.0	31.0	20.0
Normality NaOH (N):	0.100	0.100	0.100	0.100	0.100	0.100
Total NaOH added (ml):	32.5	19.7	34.0	18.7	29.8	20.5
NP:	13.8	4.8	21.3	7.3	9.3	2.7
AP:	0.63	1.56	0.31	1.56	0.31	0.31
Net NP:	13.2	3.2	21.0	5.8	9.0	2.4
NP/AP:	22.1	3.1	68.2	4.7	29.7	8.8
Total S (%):	0.09	0.07	0.09	0.07	0.05	<0.01
Sulphide S (%):	0.02	0.05	0.01	0.05	<0.01	<0.01
SO_4 (%):	0.20	0.05	0.25	0.06	0.13	<0.03
CO_3 (%):	0.19	0.16	0.36	<0.05	0.30	<0.05

DIGBY WELLS AND ASSOCIATES

Private Bag X 10046
RANDBURG
2125

CHEMICAL ANALYSIS : WATER SAMPLES	Our Ref: DIG/ 340 - 348 / A / 03 /09

Date received: 16 March 2009
Date completed: 2 April 2009 — *Project Name: NOR 335*
Quantity Analyzed: 9 — *Samples A 341 & A 342 are labbled the same*

Lab No	*A 340*	*A 341*	*A 342*
Analysis Results mg/l	**WNSWO 1**	**WNSW 02**	**WNSW 02**
Total Dissolved Solids	40	54	76
Suspended Solids	<0.4	4,4	411
Nitrate NO_3 as N	<0.1	<0.1	<0.1
Chlorides as Cl	10	11	14
Total Alkalinity as $CaCO_3$	<5.0	23	23
Fluoride as F	<0.20	<0.20	<0.20
Sulphate as SO_4	14,2	5,4	17,7
Total Hardness as $CaCO_3$	10	24	18
Calcium Hardness as $CaCO_3$	5	14	13
Magnesium Hardness as $CaCO_3$	5	10	5
Calcium as Ca	2,10	5,68	5,35
Magnesium as Mg	1,18	2,44	1,10
Sodium as Na	7,45	6,67	10,9
Potassium as K	1,78	2,78	3,74
Iron as Fe	<0.01	<0.01	39,3
Manganese as Mn	0,02	<0.01	0,29
Conductivity in mS/m	6,7	8,9	10,1
pH-Value at 25 ° C	5,67	6,65	5,85
pHs at 21 °C	10,75	8,94	9,01
Langelier Saturation Index	-5.08	-2.29	-3.16
Aluminium as Al	0,03	0,01	0,52
Bicarbonate Alkalinity as $CaCO_3$	<5.0	23	23
Free & Saline Ammonia NH_3 as N	0,55	0,68	2,00
Ortho Phosphate PO_4 as P	0,12	0,10	0,10
Sodium Absorption Ratio	1,02	0,59	1,12
Copper as Cu	<0.01	<0.01	<0.01
Total Chromium as Cr	<0.01	<0.01	<0.01
Lead as Pb	<0.01	<0.01	<0.01
Zinc as Zn	0,02	0,02	0,26

All heavy metal analyses have been performed on filtered samples.
*Tests marked with an asterisk * are not SANAS accredited*
These results are related only to the items tested

QUALITY CONTROL CHECKS			
Cation Balance	0,61	0,90	1,14
Anion Balance	0,58	0,88	1,22
% Difference	3,1	0,7	-3,6
Measured TDS	40	54	76
Calculated TDS	37	49	70
Limits > 1.0 - <1.2	1,1	1,1	1,1
Calcul TDS / E.C. (0.55 - 0.70)	0,6	0,5	0,7

P.L.G. UYS

DIGBY WELLS AND ASSOCIATES

Private Bag X 10046
RANDBURG
2125

CHEMICAL ANALYSIS : WATER SAMPLES	Our Ref: DIG/ 340 - 348 / A / 03 /09

Date received: 16 March 2009
Date completed: 2 April 2009 ***Project Name: NOR 335***
Quantity Analyzed: 9

Lab No	***A 343***	***A 344***	***A 345***
Analysis Results mg/l	**WNSW 04**	**WNSW 05**	**WNSW 07**
Total Dissolved Solids	**60**	**60**	**62**
Suspended Solids	**0,8**	**187**	**<0.4**
Nitrate NO_3 as N	**<0.1**	**<0.1**	**<0.1**
Chlorides as Cl	**11**	**15**	**15**
Total Alkalinity as $CaCO_3$	**30**	**20**	**25**
Fluoride as F	**<0.20**	**<0.20**	**<0.20**
Sulphate as SO_4	**7,0**	**9,6**	**6,8**
Total Hardness as $CaCO_3$	**33**	**25**	**28**
Calcium Hardness as $CaCO_3$	**17**	**13**	**14**
Magnesium Hardness as $CaCO_3$	**16**	**12**	**14**
Calcium as Ca	**6,88**	**5,17**	**5,49**
Magnesium as Mg	**3,80**	**2,90**	**3,41**
Sodium as Na	**7,39**	**9,25**	**8,60**
Potassium as K	**0,63**	**0,44**	**2,20**
Iron as Fe	**<0.01**	**1,34**	**0,30**
Manganese as Mn	**<0.01**	**<0.01**	**<0.01**
Conductivity in mS/m	**9,9**	**9,8**	**10,5**
pH-Value at 25 ° C	**7,55**	**6,24**	**6,99**
pHs at 21 °C	**8,74**	**8,94**	**8,90**
Langelier Saturation Index	**+0.39**	**-2.70**	**-1.91**
Aluminium as Al	**<0.01**	**0,15**	**0,0**
Bicarbonate Alkalinity as $CaCO_3$	**30**	**25**	**25**
Free & Saline Ammonia NH_3 as N	**0,88**	**0,99**	**0,84**
Ortho Phosphate PO_4 as P	**0,12**	**0,11**	**0,12**
Sodium Absorption Ratio	**0,56**	**0,81**	**0,71**
Copper as Cu	**<0.01**	**<0.01**	**<0.01**
Total Chromium as Cr	**<0.01**	**<0.01**	**<0.01**
Lead as Pb	**<0.01**	**<0.01**	**<0.01**
Zinc as Zn	**<0.01**	**0,01**	**<0.01**

All heavy metal analyses have been performed on filtered samples.
Tests marked with an asterisk * are not SANAS accredited
These results are related only to the items tested

QUALITY CONTROL CHECKS			
Cation Balance	**1,06**	**1,00**	**1,05**
Anion Balance	**1,06**	**1,02**	**1,06**
% Difference	**0,0**	**-1,2**	**-0,8**
Measured TDS	**60**	**60**	**62**
Calculated TDS	**56**	**56**	**58**
Limits > 1.0 - <1.2	**1,1**	**1,1**	**1,1**
Calcul TDS / E.C. (0.55 - 0.70)	**0,6**	**0,6**	**0,6**

P.L.G. UYS

DIGBY WELLS AND ASSOCIATES

Private Bag X 10046
RANDBURG
2125

CHEMICAL ANALYSIS : WATER SAMPLES	Our Ref: DIG/ 340 - 348 / A / 03 /09

Date received: 16 March 2009
Date completed: 2 April 2009 *Project Name: NOR 335*
Quantity Analyzed: 9

Lab No	*A 346*	*A 347*	*A 348*
Analysis Results mg/l	**WNSW 08**	**WNSW 09**	**WNSW 10**
Total Dissolved Solids	50	1300	66
Suspended Solids	<0.4	2,4	<0.4
Nitrate NO_3 as N	<0.1	<0.1	<0.1
Chlorides as Cl	12	15,0	15
Total Alkalinity as $CaCO_3$	10	162	21
Fluoride as F	<0.20	0,22	<0.20
Sulphate as SO_4	11,7	692	11
Total Hardness as $CaCO_3$	16	951	22
Calcium Hardness as $CaCO_3$	9	437	12
Magnesium Hardness as $CaCO_3$	7	514	10
Calcium as Ca	3,73	175	4,80
Magnesium as Mg	1,63	125	2,39
Sodium as Na	7,67	8,94	9,39
Potassium as K	2,34	12,2	3,96
Iron as Fe	0,26	<0.01	1,58
Manganese as Mn	<0.01	<0.01	<0.01
Conductivity in mS/m	7,78	153,8	10,0
pH-Value at 25 ° C	6,41	7,52	6,67
pHs at 21 °C	9,32	6,79	9,06
Langelier Saturation Index	-2.91	+0.73	-2.39
Aluminium as Al	0,01	<0.01	0,04
Bicarbonate Alkalinity as $CaCO_3$	15	142	21
Free & Saline Ammonia NH_3 as N	0,76	0,59	0,69
Ortho Phosphate PO_4 as P	0,28	0,12	0,12
Sodium Absorption Ratio	0,83	0,13	0,87
Copper as Cu	<0.01	<0.01	<0.01
Total Chromium as Cr	<0.01	<0.01	<0.01
Lead as Pb	<0.01	<0.01	<0.01
Zinc as Zn	0,02	0,32	0,01

All heavy metal analyses have been performed on filtered samples.
*Tests marked with an asterisk * are not SANAS accredited*
These results are related only to the items tested

QUALITY CONTROL CHECKS			
Cation Balance	0,77	19,76	1,00
Anion Balance	0,78	18,08	1,07
% Difference	-0,8	4,4	-3,5
Measured TDS	50	1300	66
Calculated TDS	46	1128	60
Limits > 1.0 - <1.2	1,1	1,2	1,1
Calcul TDS / E.C. (0.55 - 0.70)	0,6	0,7	0,6

P.L.G. UYS

DIGBY WELLS AND ASSOCIATES

Private Bag X 10046
RANDBURG
2125

CHEMICAL ANALYSIS : WATER SAMPLES	Our Ref: DIG / 158 - 162 /A /05/09

Date received: 25 May 2009
Date completed: 8 June 2009 *Project No : NOR 335*
Quantity Analyzed: 5

Lab No	*A158*	*A159*	*A160*
Analysis Results mg/l	**ZKSW 2**	**ZKSW 1**	**ZKBH 1**
Total Dissolved Solids	40	44	42
Suspended Solids	11,2	<0.4	<0.4
Nitrate NO_3 as N	<0.1	<0.1	3,10
Chlorides as Cl	9,0	10	8
Total Alkalinity as $CaCO_3$	9	10	25
Fluoride as F	<0.20	<0.20	<0.20
Sulphate as SO_4	8	9,6	<1.0
Total Hardness as $CaCO_3$	11	13	21
Calcium Hardness as $CaCO_3$	6	7	11
Magnesium Hardness as $CaCO_3$	5	6	10
Calcium as Ca	2,42	2,62	4,56
Magnesium as Mg	1,26	1,51	2,44
Sodium as Na	7,50	7,26	7,64
Potassium as K	1,55	2,02	1,52
Iron as Fe	0,11	14,23	<0.01
Manganese as Mn	<0.01	<0.01	<0.01
Conductivity in mS/m	7,54	7,81	9,07
pH-Value at 25 ° C	6,88	6,92	6,73
pHs at 21 °C	9,57	9,43	9,10
Langelier Saturation Index	-2,69	-2,51	-2,37
Aluminium as Al	<0.01	<0.01	<0.01
Bicarbonate Alkalinity as $CaCO_3$	13	15	21
Free & Saline Ammonia NH_3 as N	0,20	0,24	<0.20
Ortho Phosphate PO_4 as P	<0.1	<0.1	<0.1
Sodium Absorption Ratio	0,97	0,88	0,72
Copper as Cu	<0.01	<0.01	<0.01
Total Chromium as Cr	<0.01	<0.01	<0.01
Lead as Pb	<0.01	<0.01	<0.01
Zinc as Zn	0,01	0,01	0,02

All heavy metal analyses have been performed on filtered samples.
Tests marked with an asterisk * are not SANAS accredited
These results are related only to the items tested

QUALITY CONTROL CHECKS			
Cation Balance	0,60	0,64	0,80
Anion Balance	0,61	0,68	0,73
% Difference	-0,3	-3,2	4,9
Measured TDS	40	44	42
Calculated TDS	36	39	39
Limits > 1.0 - <1.2	1,1	1,1	1,1
Calcul TDS / E.C. (0.55 - 0.70)	0,5	0,5	0,4

P.L.G. UYS

DIGBY WELLS AND ASSOCIATES

Private Bag X 10046
RANDBURG
2125

CHEMICAL ANALYSIS : WATER SAMPLES	Our Ref: DIG/ 240 - 242 /C /06/09

Date received: 11 June 2009
Date completed: 22 June 2009
Quantity Analyzed: 3

Project Name : NOR 335

Lab No	*C240*	*C241*	*C242*
Analysis Results mg/l	**VPSW 1**	**VPSW 2**	**VPBH 1**
Total Dissolved Solids	1480	1484	1132
Suspended Solids	36,0	16,8	<0.4
Nitrate NO_3 as N	0,2	<0.1	0,2
Chlorides as Cl	4,0	4,0	7,0
Total Alkalinity as $CaCO_3$	36	59	199
Fluoride as F	<0.20	0,22	0,21
Sulphate as SO_4	950	920	587
Total Hardness as $CaCO_3$	1036	1083	518
Calcium Hardness as $CaCO_3$	517	495	322
Magnesium Hardness as $CaCO_3$	519	588	196
Calcium as Ca	207	198	129
Magnesium as Mg	126	143	47,6
Sodium as Na	7,30	7,8	96,3
Potassium as K	10,5	12,0	17,20
Iron as Fe	<0.01	<0.01	<0.01
Manganese as Mn	0,38	0,15	<0.01
Conductivity in mS/m	171,8	173,2	127
pH-Value at 25 ° C	6,95	7,32	7,57
pHs at 21 °C	7,37	7,18	6,78
Langelier Saturation Index	-0,42	+0.14	+0.79
Aluminium as Al	<0.01	0,02	<0.01
Bicarbonate Alkalinity as $CaCO_3$	36	59	199
Free & Saline Ammonia NH_3 as N	<0.20	<0.20	<0.20
Ortho Phosphate PO_4 as P	<0.1	<0.1	<0.1
Sodium Absorption Ratio	0,10	0,10	1,84
Copper as Cu	<0.01	<0.01	<0.01
Total Chromium as Cr	<0.01	<0.01	<0.01
Lead as Pb	<0.01	<0.01	<0.01
Zinc as Zn	0,09	0,04	0,18

All heavy metal analyses have been performed on filtered samples.
*Tests marked with an asterisk * are not SANAS accredited*
These results are related only to the items tested

QUALITY CONTROL CHECKS			
Cation Balance	21,30	22,30	14,98
Anion Balance	20,61	20,46	16,41
% Difference	1,6	4,3	-4,5
Measured TDS	1480	1484	1132
Calculated TDS	1327	1321	1006
Limits > 1.0 - <1.2	1,1	1,1	1,1
Calcul TDS / E.C. (0.55 - 0.70)	0,8	0,8	0,8

P.L.G. UYS